THE BIOLOGIC AND ECONOMIC ASSESSMENT OF METHYL BROMIDE

Prepared by

The National Agricultural Pesticide Impact Assessment Program (NAPIAP)

United States Department of Agriculture

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PREFACE

A pre-assessment survey revealed which commodity uses of methyl bromide were considered critical to agriculture, and which uses consumed the largest quantities of methyl bromide. As a result of the data acquired in the pre-assessment survey, the States of California, Florida, Georgia, North Carolina, and South Carolina were identified as major use States and were asked to participate in a formal assessment of the following commodities: almonds, apples, apricots, carrots, cherries, citrus, cucumbers, eggplant, forest tree transplants, grapes, melons, ornamentals/nurseries, peaches/nectarines, peppers, plums/prunes, strawberries, sweet potatoes, tobacco, tomatoes, and walnuts.

The information used in this report was obtained from participating Federal, State, and industrial specialists who cooperated with the U.S. Department of Agriculture's National Agricultural Pesticide Impact Assessment Program (USDA/NAPIAP) State Liaison Representatives and Extension specialists. Contributors met in regional enumeration meetings to transmit preliminary data. Numerous highly qualified commodity, fumigation, and regulatory specialists have contributed to the information included herein. Their names and affiliations are listed in the contributor section of this report and NAPIAP is grateful for their cooperation.

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EXECUTIVE SUMMARY

Methyl bromide is very important to United States agriculture. It is used widely as a soil fumigant and in post harvest as well as quarantine treatments to control a variety of pests on numerous crops. For many uses there are no alternative chemicals or other viable treatment options to replace methyl bromide. The loss of methyl bromide would be extremely costly to individual agricultural producers and to consumers, thus having a detrimental impact on the U.S. economy.

When the *Montreal Protocol 1991 Assessment* indicated methyl bromide was in a category of chemicals that are allegedly responsible for depleting the stratospheric ozone layer, the Environmental Protection Agency (EPA) initiated action under the Clean Air Act, which calls for a phaseout of chemicals threatening the ozone layer by the year 2000. There are many scientific uncertainties regarding methyl bromide's relationship to ozone depletion, including 1) the relative contributions of methyl bromide to the atmosphere from natural and anthropogenic sources, 2) quantification of possible reaction changes involving methyl bromide that produce the relatively unreactive form of bromine, hydrogen bromide, 3) the lifetime of methyl bromide in the atmosphere, and 4) the amount of methyl bromide emissions from agricultural uses.

Because of these unknown factors pertaining to methyl bromide and the ozone layer, as well as methyl bromide's critical role in U.S. agriculture, more scientific investigation needs to be conducted before making a determination on the removal of this substance.

Use of Methyl Bromide

According to industry sources, approximately 64 million pounds of methyl bromide were used in the United States in 1990, of which 44 to 49 million pounds were used for soil fumigation, 5 million pounds for post harvest and quarantine treatments, 4 to 9 million pounds for fumigating structures, and 6 million pounds as a chemical intermediate in manufacturing. Thus, of the total 64 million pounds used, more than 80 percent is for agriculturally related purposes.

Based upon a survey of the States to determine the most critical uses, and where these uses occurred, the National Agricultural Pesticide Impact Assessment Program (NAPIAP) assessed the benefits of methyl bromide use for soil fumigation on 21 crops in California, Florida, Georgia, North Carolina and South Carolina. In addition, data were included from Kentucky on use of methyl bromide for soil fumigation in tobacco production and from Florida for post harvest treatment of citrus. The Animal and Plant Health Inspection Service (APHIS) provided an assessment of quarantine uses, focusing on eight major fruit imports. As a soil fumigant, methyl bromide is used to control insects, plant pathogens, nematodes, and weeds. About 38 million pounds were used for soil fumigation in the five States. This represents approximately 80 percent of the total soil fumigation use and 75 percent of the agricultural use of methyl bromide in the United States. The largest soil fumigation uses were 13 million pounds for tomatoes, 6 million pounds for strawberries, 5 million for peppers, 4 million for ornamentals and nurseries, 4 million pounds for tobacco, and 2 million pounds each for grapes and melons. Use is primarily in California and Florida, accounting for 12 and 18 million pounds, respectively for the commodities included in this report.

Economic Losses

This assessment shows that actions to ban or restrict methyl bromide use in the U.S. would be costly because currently available alternative control practices are less effective or more expensive than methyl bromide. Due to the compounding effects of a likely increase in various pests, estimates cannot be made for losses after the first few years without methyl bromide. It is estimated that the annual economic loss to U.S. producers and consumers resulting from a ban of the agricultural uses of methyl bromide included in this study would be approximately $1.3 to 1.5 billion (table 1). This is an underestimate since the impacts of post-harvest, non-quarantine uses, quarantine treatments of nonfood imports, and 20 percent of the soil fumigation use are excluded from this study. Of that total, $800 to 900 million would be attributed to soil fumigation and $450 million to quarantine fumigation of imports. However, the voluntary cancellation by the registrant of Vorlex removes a major alternative to methyl bromide for melons, ornamentals, peppers, strawberries, tomatoes, and tobacco. Without Vorlex as an alternative, there would be an additional economic loss of about $200 million if methyl bromide were banned, because the remaining alternatives are less effective. About 90 percent of that additional loss would be attributed to fresh market tomatoes. Additionally, exports worth $200 million annually are treated with methyl bromide as a condition of entry to the importing country (table 2). Data were not available to estimate the value of exports treated with methyl bromide when the importing country did not require such treatment. Without effective alternatives to methyl bromide, these markets for U.S. exports would be lost; however, some of the commodities, if they could be produced in the U.S., could be sold elsewhere at a lower price. Production of some crops may shift to other countries.

The major portion of crop losses (without Vorlex as an alternative) would be attributed to fresh market tomatoes ($350 million), ornamentals ($170 million), tobacco ($130 million), peppers ($130 million), and strawberries ($110 million). Florida tomato production would decline 45 to 50 percent, strawberry production 65 to 70 percent, while Florida cucumber, eggplant, and pepper production would virtually disappear. A significant portion of the loss would be borne by U.S. consumers due to reduced supplies and higher prices of fruit, vegetables, and other crops. Imports could moderate price increases and consumer losses but magnify financial losses by U.S. producers. Countries whose exports must be fumigated before entry to the U.S. market would lose a share of that market.

A phase-out of methyl bromide use, which would occur under the Clean Air Act, would postpone annual losses. This would also provide time for the possibility for new alternatives to be developed and time for consumers and producers to adjust. However, the likelihood of developing new, effective fumigant alternatives to methyl bromide appears very remote.

Table 1 - Annual U.S. Economic Losses from a Methyl Bromide Ban

Crop	Economic Loss	
	With Vorlex	Without Vorlex 1/
	$ Millions	
SOIL FUMIGATION USES 2/		
Fruits and nuts:		
Almonds	<1	<1
Apples	<1	<1
Apricots	<1	<1
Cherries	<1	<1
Citrus 3/	25	25
Grapes	3	3
Nectarines	<1	<1
Peaches	<1	<1
Plums and Prunes	<1	<1
Strawberries 4/	106-107	111-112
Walnuts	<1	<1
Vegetables:		
Carrots	<1	<1
Cucumbers	72	72
Eggplants	12	12
Melons	29	29
Peppers	131	135
Sweet potatoes	<1	<1
Tomatoes (fresh market) 4/	157-164	327-360
Nonfood Crops:		
Forest seedlings	35	35
Ornamentals	163	170
Tobacco 4/	121-125	122-127
Total, soil fumigation use 6/	856-867	1,044-1,081
QUARANTINE USE FOR IMPORTS 5/		
Apricots	8	8
Grapes	186-187	186-187
Grapefruit	<1	<1
Lemons	<1	<1
Nectarines and Peaches	151-152	151-152
Plums	96	96
Oranges	<1	<1
Tangerines	3-7	3-7
Total, quarantine use	444-450	444-450
Total, soil fumigation quarantine uses 6/	1,300-1,317	1,488-1,531

1/ Includes impact of voluntary cancellation of Vorlex.
2/ Estimates from the NAPIAP study of soil fumigation uses.
3/ Post-harvest use in Florida.
4/ Range accounts for impact of potential increases in imports.
5/ Amortized values from estimates in the APHIS study of quarantine uses.
6/ Totals sum impacts of all commodities above.

Table 2 - U.S. Exports Treated with Methyl Bromide as a Condition of Entry by Importing Country, 1989-92 Average.[1]

Commodity	Importing Countries	U.S. Exports Treated
	$ Millions	
Fruits and Nuts:		
Cherries	Japan, Korea	43
Peaches/Nectarines	Japan, Mexico	3
Strawberries	Australia	2
Walnuts	Japan	2
Other:		
Cotton	Egypt, Bangladesh, Pakistan, El Salvador, Guatemala, Peru	121
Oak logs	EEC, Austria, Mexico	35
Total		206

[1] Estimates from APHIS study of quarantine uses.

INTRODUCTION

Methyl bromide is a widely used fumigant for controlling soil pests and protecting stored commodities. It has been in use since the early 1930's. The Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, referred to as the Montreal Protocol, recently declared that methyl bromide is an ozone depleter. This action followed information made available by assessment panels and an international workshop on methyl bromide. The Montreal Protocol, which consists of nations that have signed a treaty to protect the ozone layer, concluded in November of 1992 that by 1995 production and use of methyl bromide would be frozen at 1991 levels with exemptions for quarantine and pre-shipment uses. Further action by the Montreal Protocol will be based on upcoming scientific and technology assessments.

The Parties to the Montreal Protocol listed methyl bromide's ozone depletion potential (ODP) as 0.7 at their November 1992 meeting. ODP is based on a number of factors for the compound in question that affect atmospheric lifetime. These factors are used to determine activity on a mass per kilogram basis compared with the standard, chlorofluorocarbon-11, which has been assigned an ODP of 1. Title VI of the Clean Air Act (Stratospheric Ozone Protection), which was added in the 1990 Amendments, indicates in Section 602 that the U.S. Environmental Protection Agency (EPA) must list as a Class I ozone depleter any substance with an ODP of 0.2 or greater. Once designated, all production must be phased out by the year 2000 and a schedule must be developed to phase out use. The current scientific knowledge base related to methyl bromide in the atmosphere is considerably less than that for chlorine compounds. There are uncertainties related to 1) the relative contributions of methyl bromide from natural and anthropogenic sources, 2) quantification of possible reactions involving methyl bromide that produce the relatively unreactive form of bromine, hydrogen bromide, 3) the lifetime of methyl bromide in the atmosphere, and 4) the amount of methyl bromide emissions from agricultural uses.

Recognizing the need for a better understanding of the environmental fate of methyl bromide used in agriculture, NAPIAP has initiated support for a research program to collect and analyze quantitative data on the fate of methyl bromide in soils and in air. A group of Federal and State Agricultural Experiment Station scientists from California, Florida, and Nevada will perform research designed to: determine the volatilization rate of methyl bromide from soil; determine the impact of current management techniques on loss of methyl bromide to the atmosphere; develop new management methods to reduce loss of methyl bromide into the atmosphere; determine what factors control the movement of methyl bromide in the subsurface layer of soil; determine the mechanisms that retard the movement of methyl bromide in soil; determine the factors that promote methyl bromide degradation in soil; and determine the stability of methyl bromide in the near-surface atmosphere.

Although the Clean Air Act does not contain a risk-benefit balancing process, the U.S. Department of Agriculture recognizes the importance of determining the impacts of removing methyl bromide from agricultural use. Information relating to soil fumigation uses in this report was obtained from participating Federal, State, and industrial specialists who cooperated with NAPIAP State Liaison Representatives and who met in enumeration meetings to provide data relating to critical commodity uses of methyl bromide.

A pre-assessment survey of crop specialists revealed which commodity uses of methyl bromide are critical to agriculture and which commodities required the largest quantities of fumigant. These results

were the criteria for selection of five States (plus tobacco in Kentucky) and 21 commodities that were included in the assessment. The use of methyl bromide on selected commodities and States in this study are shown in Table 3.

According to industry sources, approximately 64 million pounds active ingredient of methyl bromide were used in the United States in 1990. A range of 44-49 million pounds were used for soil fumigation. Of the remainder, approximately 5 million pounds were used for post harvest treatments, 4-9 million pounds for structural uses, and 6 million pounds as a chemical intermediate in manufacturing. In this assessment, NAPIAP estimated that about 38 million pounds were used for soil fumigation on the study crops in 5 States (plus tobacco in Kentucky). This accounts for approximately 80 percent of the total U.S. soil fumigation use of methyl bromide (Table 3). The largest single commodity use was 13.1 million pounds for tomatoes, of which 10.9 million pounds were used in Florida. Other large uses were 5.7 million pounds for strawberries, 4.5 million for peppers, 3.7 million for ornamentals and nursery, 3.6 million for tobacco, and 2 million pounds each for grapes and melons. Use was concentrated in California and Florida, accounting for 11.9 and 18.1 million pounds, respectively.

Methyl bromide is a unique fumigant that cannot be assessed for its value in the manner of a conventional insecticide, fungicide, herbicide, or nematicide, because as a fumigant/sterilant, methyl bromide serves the combined function of all of these pesticides. Methyl bromide is also unique because there are few alternative fumigants. All alternatives to methyl bromide have use limitations and two alternatives (metam sodium and Vorlex) are under regulatory scrutiny because of environmental concerns. Since the beginning of this assessment, the registrant of the major fumigant alternative, Vorlex, has petitioned the U.S. Environmental Protection Agency (USEPA) for voluntary registration cancellation. Therefore, even though Vorlex has been the most popular fumigant alternative to methyl bromide, Vorlex will no longer be available in the near future. For those crops and acres where Vorlex would have been used as an alternative to methyl bromide, yield losses and economic effects were adjusted to account for the loss of both materials.

Conventional pesticides, when removed from use, can often be replaced by one or more alternative pesticides, resulting in minimal economic losses. When these economic losses occur, they are normally an annual phenomenon. However, this assessment demonstrates that a unique fumigant like methyl bromide, when withdrawn from use, can result in progressively increasing economic losses for several years, and may culminate in the total destruction of the commodity and its allied industry. This occurs because of the progressively increasing infestation of pests (pathogens, insects, nematodes, weeds) that survive consecutive plantings and are ultimately transmitted to established production fields on multiyear crops. The cost and reduction of production eventually causes the grower to regard the crop as unprofitable. Many of these crops are geographically confined so that production losses cannot be replaced by other growing regions.

Another use of methyl bromide is in plastic-culture (plastic mulching). Plastic culture has become the standard agronomic system for numerous crops in some States and is gradually being accepted in others. Plastic culture's evident advantages are water and soil conservation, temperature modification, earlier harvest, suppression of weeds, the ability to double-crop, and the reduction of multiple applications of alternative pesticides. This cultural method results in reduced environmental problems (e.g., water contamination, endangered species, etc.) reduced food residues, applicator exposure, pesticide drift, and hazards to crop harvesters.

Organization of this Report

This document is organized into three sections. Section I deals with the uses of methyl bromide for soil fumigation. Section II discusses the economic impacts of banning methyl bromide for soil fumigation, and Section III covers the economic impacts of losing methyl bromide as a quarantine treatment. Appendices and References for sections II and III can be found at the end of the document.

ALTERNATIVE FUMIGANTS

Most alternative chemicals, used in lieu of preferred treatments, have shortcomings. These alternatives may not provide complete control of pest species and season-long protection, and may also result in reduced yields, require additional rescue treatments, or cause undesirable plant responses. However, alternatives provide some protection against pests and allow the economic production of a commodity (Table 4).

Use of Telone is not legal in California. Uses of this product were canceled in 1990 because significant airborne levels were detected and the material was listed as undesirable because of toxicity according to Proposition 65. Cancellation of Telone resulted in 1-1.5 million lb of additional methyl bromide use.

Regarding the two commonly-used fumigant alternatives (Vorlex [1,3-D plus methyl isothiocyanate] and Vapam [metam sodium-which also releases methyl isothiocyanate]) Vorlex is by far the most reliable alternative, while Vapam is less consistent and does not allow commodity production at economic levels (Table 4). This benefits-assessment was completed with the presumption that both fumigant alternatives would remain available. However, NAPIAP learned during the completion of the preliminary draft of this benefits-assessment that Vorlex will soon be voluntarily canceled by the manufacturer (NOR-AM Chemical Company) because of prohibitive cost of reregistration. Therefore, only Vapam will be available as an alternative fumigant to methyl bromide. The implications of this development for yield and economic losses were evaluated for melons, ornamentals, peppers, strawberries, tobacco, and tomatoes.

Another fumigant that is briefly mentioned in this report is Basamid (dazomet-a granular formulation). Basamid granules hydrolyze in the soil, releasing methyl isothiocyanate. Registration on food sites has not occurred in the United States and is limited to tobacco, turf, ornamentals, and bulk soil. Therefore, dazomet is not an alternative to methyl bromide, except for a limited number of soil uses.

Table 3. Use of methyl bromide in study area.

Crop	California	Florida	Georgia	North Carolina	South Carolina	Kentucky (tobacco)	Total
	Thousand pounds a.i.						
Almonds	721						721
Apples	180						180
Apricots	30						30
Carrots	2						2
Cherries	90						90
Citrus		102					102
Eggplant		410					410
Forest tree seedlings	4	48	160	40	68		320
Grapes	1,935						1,935
Melons	224	1,060	405	76	198		1,963
Nectarines	316						316
Ornamentals/ nursery	2,482	623		608			3,713
Peaches	634						634
Peppers	238	3,927	200	148			4,512
Plums/prunes	296						296
Strawberries	4,327	1,069		165	147		5,708
Sweet potatoes	9						9
Tobacco			362	1,906	414	1,000	3,683
Tomatoes	237	10,937	698	280	960		13,111
Walnuts	192						192
Total	11,916	18,177	1,824	3,223	1,788	1,000	37,928

Table 4. Pest control ratings for methyl bromide, Vorlex and metam-sodium in Florida

Chemical Name	Amount Required for Treatment (lb/a.i.)	Treatment Cost of Material ($)	Pest Control Ratings (Any rating less than those listed for each pest group provide unacceptable control for growers.)			
			Ratings: 10 = Excellent; 1 = Poor			
			Weeds (9.3)	Insects (9)	Nematodes (9)	Pathogens (7.5)
Methyl Bromide **** 67/33	200	290	9	10	10	10
Methyl Bromide *** 98/2	200	184	10	10	10	7.5
Vorlex	87.7	381	*7	10	**9	7.5
Metam-sodium	190	250	*5	5	**7	***3

* Nutsedge (nutgrass), a severe weed on vegetables grown in Florida, is not controlled by either metam-sodium or Vorlex.

** Control of nematodes is dependent on method of application. Vapam and Vorlex are usually applied through chisels so nematode control is often limited to a narrow band on each side of the chisel. Also, Vapam requires water to activate its active ingredient.

*** Metam-sodium does not control _Fusarium_ or _Verticillium_ wilts.

**** Methyl bromide 67/33 contains 67 percent methyl bromide and 33 percent chloropicrin. Methyl bromide 98/2 contains 98 percent methyl bromide and 2 percent chloropicrin.

SOIL FUMIGANT USE OF METHYL BROMIDE BY COMMODITY

This section contains benefits assessment data submitted by the assessment participants. The critical considerations that underlie the presumed changes in production that are expected to result from two scenarios are described for each commodity. These scenarios are:

A. The effects of losing methyl bromide but retaining alternative fumigant chemicals.
B. The effects of losing methyl bromide and all fumigant alternatives.

For certain commodities. Scenario A was considered identical to Scenario B because no alternative control methods were deemed to be effective.

Consequences resulting from the restricted use of fumigants that are described under each scenario apply ONLY to those acres currently treated with methyl bromide. The production, use, yield reduction estimates, and other data elements appear in tables.

The ultimate losses shown in the tables are not to be construed as the total national effect for these commodities. That evaluation is depicted in the Economic Analysis prepared by the Economic Research Service of USDA which is presented later in this report.

A pre-assessment survey (of universities) revealed commodity uses of methyl bromide that are critical to agriculture and which commodities utilize the greatest quantities. These results were the criteria for selection of five States and 21 commodities that were included in the assessment. The selected States (California, Florida, Georgia, North Carolina, South Carolina) were provided with assessment evaluation queries regarding the critical commodity uses and data enumeration meetings were held with the NAPIAP State Liaison Representatives and agricultural commodity, chemical, and crop specialists. Following tabulation of these data, they were provided to contributors for review and corrections.

ALMONDS
(California)

California is the world's leading supplier of almonds for fresh nuts and nut products. With 430,000 acres, the almond industry has a pronounced impact on the economy of California and the United States as reflected in Table 5. Methyl bromide is applied to limited almond crop acreage, before replanting trees, but is considered essential where it is used.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Five percent of the acres will be allowed to lie fallow so that infestations will recede. This will mean a 100 percent production loss on these acres for four years.
2. Eighty-five percent of the acres will be treated with metam-sodium at a cost of $525 per acre.
3. Five percent of the acres will receive multiple applications of nematicides, with unpredictable control results.
4. Five percent of the acres will be planted without pesticides, and could go out of production.

Scenario B: No fumigants available.

1. Twenty percent of the acreage would be allowed to lie fallow for four years. This would mean a 100 percent production loss for four years.[1]
2. Five percent of the acres would be planted without chemical treatment. Production could cease for these acres.
3. Seventy-five percent of the acres would not be planted, representing a total loss of that potential production.

APPLES
(California)

Apple trees are vulnerable to soil pests, beginning at the seedling stage. Methyl bromide has had a critical use in apple tree seedling establishment as shown in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Twenty percent of the acres will be allowed to lie fallow for four years, with a total loss of production.
2. Seventy percent of the acres will be treated with metam-sodium at a cost of $525 per acre.
3. Five percent of the acres will be planted with no treatment, and could go out of production.
4. Five percent of the acres will receive multiple treatments of nematicides with various responses.

Scenario B: No fumigants available.

1. Ninety percent of the acres will be allowed to lie fallow, with a total loss of production for four years.
2. Five percent of the acres will be planted to apples without treatment and could go out of production.
3. Five percent of the acres will no longer be planted to apples, with the loss of all production.

APRICOTS
(California)

Tree decline due to soil pests is extremely common among peaches, nectarines, and apricots. Apricots have an extremely high potential for yield loss as shown in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Twenty percent of the acres will be allowed to lie fallow, with a total loss of production for four years.
2. Seventy percent of the acres will be treated with metam-sodium, at a cost of $525 per acre.

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[1]When additional acreage are fallowed in subsequent years the production losses are compounded.

3. Five percent of the acres will receive multiple treatments of various nematicides, with a variety of responses.
4. Five percent of the acres will be planted without treatment and could go out of production.

Scenario B: No fumigants available.

1. Ninety percent of the acres will be allowed to lie fallow with a total loss of production for four years.
2. Five percent of the acres will be planted without treatment and could go out of production.
3. Five percent of the acres will not be treated and will sustain a total loss of production.

CARROTS
(California)

Carrot is a high yielding crop with great dependency on fumigation of infested soils. Serious yield losses are readily observed from infested acreage without proper preplant treatment as observed in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Ten percent of the acres will be rotated with a total production loss of three to five years.
2. Ninety percent of the acres will be treated with metam-sodium at a cost of $525 per acre.

Scenario B: No fumigants available.

One hundred percent of the treated acres will be placed in rotation, with a total loss c production for three to five years.

CHERRIES
(California)

The cherry industry is especially vulnerable to the ravages of soil-borne diseases and other pests. The crop is intensely commercialized in both domestic and foreign markets, and has been the subject of intense negotiation in trade talks The economic effect of losing methyl bromide is evident in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Twenty percent of the acres would be allowed to lie fallow with a total loss of production for four years.
2. Seventy percent of the acres will be treated with metam-sodium at a cost of $525 per acre.
3. Five percent of the acres will be treated with multiple applications of nematicides with various responses.
4. Five percent of the acres will be planted with no treatment and could be lost to production.

Table 5. The use of soil-applied methyl bromide on fruits, nuts, vegetables and tobacco.

Commodity	State	Production Acres	Production Total Tons	Acres Treated	Application Rate (lb/A)	Treatment Cost Including Application ($/A)	Yield Loss W/O CH_3Br (Tons)	Yield Loss W/O Fumigants (Tons)
Almonds[illegible]	California	430,000	244,254	1,803	400	1,000	13.3 in production plus 63.6 in fallow. Total = 76.9	13.3 in production, plus 252.4 in fallow, plus 947 through not planting, plus 270.5 loss because of reduced production in affected orchards. Total = 1483.2.
Apples[1]	California	32,600	337,500	450	400	610	2,106	4,680/yr for four years followed by loss of 1,170/yr.
Apricots[1]	California	19,303	131,297	75	400	550	157.5	525/yr for four years followed by 131.25/yr thereafter.
Carrots[1]	California	56,000	869,600	9	150 Plant Bed 300 Broadcast	225 or 400 w/tarp	13.95	13.95/yr for 3-5 years after each crop.
Cherries[1]	California	12,000	24,000	224	400	550	126	504/yr for four years followed by 126/yr thereafter. Also would sustain a continual loss of 25.2 because of unplanted trees.
Cucumbers[2]	Florida	17,110	189,150 (Cucumbers are double crop after tomato or pepper)	0	0	0	189,150	189,150
Eggplant[2]	Florida	2,050	26,200	2,050	200	199	26,200	26,200
Grapes[3]	California	779,400	5,269,699	4,838	400	775	13,061	43,542 increasing progressively to 140,292 on CH_3Br treated acreage for one years planting. Loss effect would be duplicated annually. Uncontrolled infestations would spread quickly to other lands in succeeding years suggesting a long term potential loss of 4.86 millions.

Table 5 (cont). The use of soil-applied methyl bromide on fruits, nuts, vegetables and tobacco.

Commodity	State	Production Acres	Production Total Tons	Acres Treated	Application Rate (lb/A)	Treatment Cost Including Application ($/A)	Yield Loss W/O CH_3Br (Tons)	Yield Loss W/O Fumigants (Tons)
Melons[2]	California	106,400	830,500	559	400	600	4,366	91,686 for 3-5 years till rotation of crop completed.
	Florida	53,000	450,000	10,600	100	107	84,800	No non-chemical alternatives. Move to new land plus cost of manual labor.
	Georgia	6,000	72,980,000[4]	1,800	225	200	6,568,200[4] increasing to 15,325,380 over time.	6,568,200[4] increasing to 15,325,380 over time.
	North Carolina	3,982	12,904,000[4]	380	200	184	369,428[4] increasing to 861,999 over time.	369,428[4] increasing to 861,999 over time.
	South Carolina	2,200	3,150	990	200	200	3,150	3,150
Nectarines[1]	California	29,100	257,950	791	400	662.50	2,009	3,215/yr for four years plus 4,420/yr due to non-planting progressively thereafter.
Peaches[1]	California	68,786	704,890	1,586	400	662.50	3,965	16,176/yr for four years 3,965/yr thereafter. Plus 8,897 from not planting.

Table 5 (cont). The use of soil-applied methyl bromide on fruits, nuts, vegetables and tobacco.

Commodity	State	Production Acres	Production Total Tons	Acres Treated	Application Rate (lb/A)	Treatment Cost Including Application ($/A)	Yield Loss W/O CH_3Br (Tons)	Yield Loss W/O Fumigants (Tons)
Peppers[2]	California	23,700	296,250	594	400	600	7,425 for [5] acres of crop rotation for 3-5 years.	35,357 Total loss for[5] all acreage in crop rotation for 3-5 years.
	Florida	23,000	244,995	19,635	200	199	With Vorlex 152,995. With Vapam 38,249. Total = 191,244. Without Vorlex as alternative, total = 201,965.	232,000
	Georgia	5,000	76,500	1,000	200	300	22,950 with progressively increasing losses.	30,600 with progressively increasing losses.
	North Carolina	6,718	52,468	739	200	184	1,732 in first year progressing to 4,040 in 2-3 years in both instances. Without Vorlex as alternative, loss is 2,800 in first year.	
	South Carolina	NO USE	REPORTED					
Plums/Prunes[1]	California	105,700	1,038,000	740	400	550	1,554	6,216 for two years progressing to 16,516 thereafter.
Strawberries[2]	California	19,500	491,452	17,306	250	1,110[6]	65,415	436,111 first year and 440,563 by second or third year.
	Florida	5,400	55,800	5,346	200	199	12,527 using Vorlex and 24,855 using Vapam. Total 37,382. Without Vorlex as an alternative, 42,225.	55,063.8 first year and eventual progressive losses on new acreages.

Table 5 (cont). The use of soil-applied methyl bromide on fruits, nuts, vegetables and tobacco.

Commodity	State	Production Acres	Production Total Tons	Acres Treated	Application Rate (lb/A)	Treatment Cost Including Application ($/A)	Yield Loss W/O CH_3Br (Tons)	Yield Loss W/O Fumigants (Tons)
	North Carolina	2,000	7,150	660	250	$850	Avg. 832 tons with progressive annual losses until entire production is lost.	
	South Carolina	1,100	3,520	737	200	285	Est. - 1,180 to estimated 1,800	Est. - 1,180 Progressing by third year.
Sweet Potatoes[3]	California	8,300	72,700	45	200	349	118.3	351 when crop is rotated. Otherwise 179 annual total crop loss.
Tobacco[2]	Georgia Field Transpl.	41,500	47,517	Not given	8	30	4,751.8 Without Vorlex, 5,040.	4,751.8
	Plant Bed	850	Not Applicable[7]	850	426	1,815	Progressively increasing losses included above.	
	Kentucky Field Transpl. Plant Bed	 178,050 4,000	 199,418 Not Applicable	 Not given 2,000	 Not given 500	 Not given 1,000	Comments indicate potential[8] losses of 2,200.	
	North Carolina Field Transpl. Plant Bed	 289,000 4,566	 259,119 Not Applicable	 0 4,475	 0 426	 0 1,135	29,512[9] Progressively increasing damage included above.	
	South Carolina Field Transpl.	 49,500	 53,398	 Not given	 Not given	 Not given	Increased costs of alternative measures[9] for plant bed production.	
	Plant Bed	1,000	Not Applicable	950	436	1,146	As above.	
Tomatoes[2]	California[10]	38,000	479,000	592	400	1,865	5,147	1,865 plus 17,354 lost to rotation = 19,219.

Table 5 (cont). The use of soil-applied methyl bromide on fruits, nuts, vegetables and tobacco.

Commodity	State	Production Acres	Production Total Tons	Acres Treated	Application Rate (lb/A)	Treatment Cost Including Application ($/A)	Yield Loss W/O CH_3Br (Tons)	Yield Loss W/O Fumigants (Tons)
	Florida[10]	55,800	825,840	54,684	200	199	161,865 Without Vorlex as alternative, 404,661.	Non pesticide alternatives do not exist. Must move to new land and use manual weeding, but this is not feasible because of the cost of new land.
	Georgia	3,100	36,800	2,790	250	250 Less mulch	16,740 loss in year 1 increasing to 23,436 thereafter.	
	North Carolina	3,387	49,496	1,400	200	184 Less mulch	10,220 in year 1 increasing to 14,308 thereafter.	
	South Carolina	4,000	70,000	4,000	240	235	21,000 lost the first year increasing to loss of 63,000 by the third year.	
Walnuts[1]	California	181,000	240,481	481	400	550	500.5	625.3 Due to discontinued planting, will also lose production of 469/yr on a progressive basis.

[1] Data for 1990
[2] Data for 1989 - 1990 (Avg.)
[3] Data for 1991 - 1992 (Avg.)
[4] Total number fruits. Weight conversion not available.
[5] Additional loss includes double cropping carrots for 3-4 years.
[6] Including plastic mulch.
[7] 1 Acre plant bed provides approximately 50 A field Tobacco.
[8] Plant seed-bed fumigation is regarded as essential to tobacco production in Kentucky.
[9] See Scenario comments.
[10] Fresh market only.

Cherries (continued)

Scenario B: No fumigants available.

1. Ninety percent of the acres will be allowed to lie fallow with a total loss of production for four years.
2. Five percent of the acres will be planted with no treatment, and could go out of production.
3. Five percent of the acres will go out of production immediately.

Remarks submitted by contributors:

1. Vapam is a good substitute, but is very costly to apply. Growers would probably not use Vapam. This would increase tree loss.
2. There are no acceptable non-chemical alternatives.
3. Possible 25 percent tree loss in the initial set-back for planting untreated trees.

CUCUMBERS
(Florida)

Florida has over 17,000 acres of cucumber production, and is a unique producing State because no preplant application of pesticides (including methyl bromide) is made to the soil (Table 5)--at least, not for the purpose of growing cucumbers. Growers take advantage of Florida's prolonged growing season by double cropping cucumbers on land that previously had been treated with methyl bromide, as well as planted and harvested with tomatoes or peppers, using plastic mulch. The feature of methyl bromide which allows Florida to use the double cropping system is methyl bromide's prolonged control of weeds and disease. Cucumbers could not be grown commercially without these chemical controls.

Scenario A: Methyl bromide canceled, other fumigants available.

1. There are no acceptable chemical alternatives.

2. It would not be feasible to produce cucumbers if methyl bromide is not available because other chemical alternatives (metam-sodium, Vorlex) do not provide enough pest control to provide a marketable crop.

Scenario B: No fumigants available.

1. Two percent of the acres would be relocated on "new" land at a preparation cost of $2,000 per acre plus the cost of land.
2. Nonchemical alternatives are not acceptable options.

Remarks submitted by contributors:

1. Methyl bromide plays a significant role in the full-bed plastic mulch production system in Florida grown vegetables.
2. There are no acceptable non-chemical alternatives.

3. Nonchemical alternatives, such as biological control, crop rotation, genetic resistance, integrated pest management, irradiation, prevention, solarization, and steam sterilization are not effective or economical as nonchemical alternatives to methyl bromide.
4. "New" land means land in native vegetation. Florida has little "new" land available. The cost of moving to "new" land has become prohibitive.

EGGPLANT
(Florida)

Methyl bromide is a significant part of the full-bed plastic mulch system for eggplant production. The production and yield information is provided in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.
No acceptable chemical alternatives exist.

Scenario B: No fumigants available.

1. Two percent of the acreage will be moved to "new land" at a cost of $2,000 per acre in preparation, plus the cost of the land.
2. Nonchemical alternatives are not effective in controlling pests.

Remarks submitted by contributors:

Metam sodium is not an effective alternative because it does not adequately control the main pest of eggplant, root-knot nematodes. Vorlex would provide better pest control than metam sodium, but Vorlex's high cost would preclude its use by eggplant producers.

FOREST TREE TRANSPLANTS
(California, Florida, Georgia,
North Carolina, South Carolina)

Forest tree seedling and transplant nurseries are difficult to assess and survey. This is because seedling beds are prepared by Federal, State, commercial, and private entities. Consequently, one can easily overlook and may possibly underestimate the total acres in production, Our estimates are in Table 6.

Scenario A: Methyl bromide canceled, other fumigants available.

California (all varieties except bare root conifers)

1. One hundred percent of the acres will be treated with metam-sodium at an average cost of $450 per acre.
2. One hundred percent of the acres will be treated with a herbicide for an average of 1.5 treatments at a cost of $200 per acre.
3. An average of 88 percent of the acres will receive a fungicide treatment an average of 3.5 times at an average cost of $175 per acre.

California (Bare root conifers)

1. One hundred percent of the acres will be treated once with the following chemicals at the stated cost.

Chloropicrin	Cost unknown
Basamid (dazomet)	$1,200/A
Metam-sodium	$900/A
Vorlex (1,3-D + MIC)	$900/A
Round-up (glyphosate)	$40/A

2. One hundred percent of these same acres will receive two treatments of Goal (oxyfluorfen).
3. If available (since it is still in the experimental stage), one hundred percent of the above acres will receive a treatment of Forsi-mycostop.

Florida (Bare root conifers)

1. Some of the acres will be treated with dazomet at a total cost of $1,310 per acre.
2. Some of the acres will be treated with metam-sodium at a total cost of $960 per acre.

Georgia

1. Some acres will be treated with metam-sodium at a total cost of $700 per acre. This is not considered an adequate or acceptable treatment.
2. Some acres will be treated also with Sectagon (metam-sodium) and Basamid (dazomet). Neither are considered adequate or acceptable treatments.

North Carolina

1. Ten percent of the acres will be treated with Vapam (metam-sodium) at a total cost of $1,272 per acre.
2. Ten percent of the acres will be treated with Sectagon (metam-sodium) at a cost of $1,231 per acre.
3. Ten percent of the acres will be treated with Basamid (dazomet) at a cost of $1,825 per acre.
4. Seventy percent of the acres will be treated with Nemacur (fenamiphos) at a cost of $165 per acre.
5. The Nemacur treated acreage will also be treated with the herbicides Goal (oxyfluorfen) plus Poast (sethoxydim) at a cost of $140 per acre.
6. The Nemacur treated acreage will also be hand-weeded on four occasions at a cost of $300 per acre.

South Carolina

One hundred percent of acres will require hand-weeding in addition to herbicides. Cost estimate not provided.

Scenario B: No fumigants available.

California (all varieties except bare-root conifers)

1. One hundred percent of the acres will require hand-weeding on an average of 2.5 times and at an average cost of $250 per acre.
2. One hundred percent of the acres will require replant of declined trees on two occasions at an average cost of $150 per acre.
3. Some acres will be allowed to lie fallow for a minimum of two years with a 100 percent loss of production for the fallow periods.

California (Bare-root conifers)

1. One hundred percent of the acres will be treated with mechanical cultivation on six occasions at a cost of $20 per acre.
2. One hundred percent of the acres will be hand-weeded on twelve occasions at a cost of $220 per acre.
3. There will be an attempt by 100 percent of the acreage to practice solarization with cabbage, but this is an experimental practice and is not refined.

Florida (all varieties except bare-root conifers)

1. Some acreage would be moved to new land sites at a cost of $1,550 per acre not including the cost of land.
2. One hundred percent of all acres would be rotated for no less than two years, possibly more. This would mean a 100 percent production loss for the rotation period.

North Carolina

1. Five percent of the acres will be treated with steam at a fuel cost (estimated) of $46,400 plus cost of equipment.
2. One hundred percent of the acres will be hand-weeded at a cost of $2,400 per acre.

South Carolina

No assessment for this option was provided.

Remarks submitted by contributors:

1. Currently there are no known non-chemical alternatives for controlling soil pathogens.
2. Basamid is less effective than methyl bromide in controlling weeds.
3. Non-chemical alternatives such as biological control, crop rotation, genetic resistance, integrated pest management, irradiation, prevention, solarization, and steam sterilization are not effective or economical as non-chemical alternatives to methyl bromide.

4. While Florida shows that without methyl bromide a 20 percent loss in yield for the first year would occur, it is also anticipated that 40 percent of the production acreage would be lost by the second year. This anticipated loss represents all nurseries in the private sector. With no chemical control, there would be a first year loss of 60 percent and a general production loss of 40 percent in the second year.
5. Tree nurseries are an 8.8 billion dollar industry in Georgia. Alternative treatments would need to be applied every year. It would also take more land to provide acceptable production using the alternatives.
6. The "America the Beautiful" legislation is part of the Forestry Title in the 1990 Farm Bill. In addition, Congress enacted The Forest Stewardship and Stewardship Incentive programs. The total goal is to plant and care for an additional one billion healthy trees a year. Fumigation with methyl bromide is vital to production of these one billion healthy seedlings. Three well-placed trees around a home have been shown to reduce air conditioning costs from 10-50 percent.
7. Weed control without methyl bromide will be less efficient.
8. Plant stands will be reduced because of inconsistencies of alternative products for pest control.
9. Aeration time for alternative fumigants will be much longer and require bioassays to determine dissipation.
10. Under wet and cool conditions aeration will be considerably delayed, causing inconsistency in plants, which will lead to non-uniformity and reduced value.
11. The overall effects could be expected to reduce saleable plants per acre by 30 to 50 percent.
12. Without methyl bromide there would be no disease control.

GRAPES
(including raisin, table, and wine)
(California)

Grapes are grown and considered separately with regard to the end use of the commodity. In order to ease the burden of evaluation in this benefits assessment, the California participants extended the added effort to combine the respective varieties and specialty uses of grapes considered in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Twenty percent of the acreage would be allowed to lie fallow for four years in order to allow infestations to diminish. This would mean a 100 percent loss of production on these lands for four years.
2. Seventy percent of the acreage would receive metam-sodium at a cost of $525 per acre.
3. Five percent of the acres would be treated with non-fumigant nematicides with variable costs.
4. Five percent of the acres would be planted without treatment and be predisposed to abandon production.

Table 6. The use of soil-applied methyl bromide on forest tree seedlings, 1989-90 (avg.).

State	Production Acres	Production Total Seedlings	Acres Treated	Application Rate (lb/A)	Treatment Cost Including Application ($/A)	Yield Loss[4] W/O CH_3Br ($)	Yield Loss[4] W/O Fumigants ($)
California[1]	150	40 million	18	218	1,200	675,000 the first year. Losses would increase progressively until total loss of over 2,000,000.	
Florida	138	82 million	138	350	1,077	2,463,300[2] in first year.	4,926,600 in year two. Land production area would quadruple but damage level would persist.
Georgia	798	558.6 million	399	400	950	20,947,500 plus cost of additional land for rotation and fallow.	
North Carolina	150	105 million	100	400	950	5,250,000	Impossible to estimate. It will be in excess of 5,250,000.
South Carolina	210	147 million	210	325	950	5,512,500[3]	5,512,500 plus cost of hand weeding.

[1]California data represents the combined values of two major nurseries.
[2]NAPIAP estimates $.15/seedling based on grower survey.
[3]Not given: NAPIAP estimates typical 25% loss on treated acreage.
[4]For bare root seedlings only.

Grapes (continued)

Scenario B: No fumigants available.

1. Sixty-five percent of the acreage would be allowed to lie fallow for four years with 100 percent loss in production.
2. Production would be abandoned on thirty percent of the acreage because it is infested with *Armillaria* sp., and grapes can not be grown on such land without methyl bromide.
3. Five percent of the acres would be planted without chemical control and would be predisposed to abandoning production.

Remarks submitted by contributors:

1. The 40 percent first year loss shown for Scenario B would be compounded each year, eventually resulting in a 100 percent loss.
2. Regarding the renovation of vineyards relative to removing and reestablishing a vineyard, which is an expensive process (usually exceeding $6,700/acre) the following statements were made, "Nematode infestations are a major threat to the longevity of grape vines.... Populations of nematodes and other pests are reduced by a combination of chemical fumigation and solar heating of the soil. The bare field is then fumigated with chlorpicrin and methyl bromide and ripped one more time in one direction [2]....The Paviches[3] also use the more conventional method of controlling nematodes and other soil-borne pests: fumigating the soil prior to planting the grapes (with chloropicrin and methyl bromide) and maintaining the soil in bare fallow condition for a period of 2 to 3 years between vineyard removal and reestablishment."

MELONS

(California, Florida, Georgia,
North Carolina and South Carolina)

Melons are treated as a single commodity in this assessment since they are similar in culture, pests and pest management. State and industry crop specialists have grouped these data together from the different types of melons. Production and loss information are shown in Table 5. Some data was submitted as numbers of fruits rather than in tons. No attempts were made to convert these figures to tons of production, as no accurate conversion guidelines exist.

Scenario A: Methyl bromide canceled, other fumigants available.

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[2]Committee on the role of alternative farming methods in modern production agriculture. 1989. Fresh grapes in California and Arizona: Stephen Pavich and Sons in alternative Agriculture, National Research Council, National Acad. Press, Washington, DC.

[3]Viticulturists

California

1. Ten percent of the acres will be placed in crop rotation for 3-5 years. Because melons are commonly double-cropped with carrots, this would mean a loss of all melon and carrot production on that acreage for 3-5 years.

2. Ninety percent of the acres will be treated with metam-sodium, at a cost of $525 per acre.

Georgia

1. Fifty percent of the acres will be treated with metam-sodium, at a cost of $700/A. These acres will sustain a 50 percent loss in production.
2. Ten percent of the acres will be treated with Vorlex at a cost of $550/A. These acres will sustain a 50 percent loss in production.

North Carolina

1. Fifty percent of the acres will be treated with metam-sodium at a cost of $700/A, and these acres would sustain a 50 percent loss of production.
2. Ten percent of the acres will be treated with Vorlex at a cost of $555/A and these acres will sustain a 50 percent loss of production.

South Carolina

Because melons are grown on plastic, and nutsedge control using methyl bromide is essential, melon production will cease. Nutsedge can pierce through plastic mulch and undo the benefits of the mulch.

Scenario B: No fumigants available.

California

One hundred percent of the acres will be placed in rotation crops with 100 percent loss of production for 3-5 years.

Georgia

One hundred percent of the acres will be relocated to "new ground." This would require the cost of clearing the land and the cost of the land itself.

North Carolina

One hundred percent of the acres will be rotated to cleared land at a land clearing cost of $1,000/A plus land acquisition costs.

South Carolina

Melons will not be grown by the simple fact of losing methyl bromide. See Scenario A.

Remarks submitted by contributors:

1. Melons are normally double-cropped following cucumbers or squash.
2. Most melon crops are grown on plastic mulch with drip irrigation.

NECTARINES
(California)

Nectarines are a major fruit commodity in California. Reliable production is strongly dependent on the availability of methyl bromide as shown in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Ninety percent of currently treated acreage will be treated with metam-sodium at a cost of $525 per acre.
2. Five percent will be treated with various nematicides in multiple treatments. Success will be variable.
3. Five percent will be planted without a fumigant and could go out of production.

Scenario B: No fumigants available.

1. Forty percent of currently treated acreage will be allowed to lie fallow, at a loss of 100 percent for four years to allow infestations to recede. Fallow land may be diverted to alfalfa during the same period.
2. Five percent will be planted with no pesticide treatments and could go out of production.
3. Fifty-five percent of the acres will be abandoned, with production ceasing on these acres.

ORNAMENTALS/NURSERIES
(California, Florida, North Carolina,
South Carolina)

Because commodities in the ornamentals and nursery industries have a value related to aesthetic rather than consumer utilization, the losses have been reduced to dollar value (Table 7). Alternatives have been segmented for individual States because the respective proportion of remedial treatments are not similar to each other.

Scenario A: Methyl bromide canceled, other fumigants available.

<u>California</u>

a. Greenhouses: Steam treatment will be used in 100 percent of greenhouses on 1-3 occasions per year at a cost of $4,500 - $7,500 per acre, plus the cost of fuel.
b. Field:
    1. One hundred percent of all acres will receive metam-sodium at an average cost of $550 per acre.
    2. One hundred percent of these same acres will receive 1-2 treatments with a herbicide at an average cost of $200 per acre.

3. An average of 87.5 percent of the above acres will also be treated with a fungicide, for an average of three applications and at a cost of $175 per acre.
4. A nematicide will also be applied to fifty percent of the above acres at a cost of roughly $175 per acre.

Florida (Caladium sp)

One hundred percent of the acreage will be treated with metam-sodium at a rate of $1,175/A (including application).

Florida (Cut flowers)

1. Ninety-eight percent of the acreage will be treated with Vorlex at a cost of $265 per acre.
2. Two percent of the acres will be treated with metam-sodium at a cost of $396 per acre.

North Carolina

1. Ten percent of the acres will be treated with Vapam (metam-sodium) at a cost of $472 per acre.
2. Ten percent of the acres will be treated with Sectagon (metam-sodium) at a cost of $431 per acre.
3. Ten percent of the acres will be treated with Basamid (dazomet) at a cost of $1,025 per acre.
4. Seventy percent of the acres will be treated with Nemacur (fenamiphos) at a cost of $115 per acre.
5. All of the above acres will be hand-weeded four times at a total cost of $6,000/A ($250 per acre for weeding).

South Carolina

South Carolina is promoting the use of "soil-less" planting mixtures. Asserts minimal methyl bromide use.

Scenario B: No fumigants available.

California

a. Greenhouses: One hundred percent would be treated with steam 1-3 times at a cost of $4,500-$7,500 plus the cost of fuel.
b. Field:
   1. One hundred percent of the acreage would require hand-weeding two to three times at an average cost of $250/weeding/acre.
   2. One hundred percent of the same acreage would require replant of "die-offs" on two occasions at an average cost of $150 per acre.
   3. Some acreage would be allowed to lie fallow for four years with a total loss of production.

Florida

1. One hundred percent of the acreage would require hand-weeding. A study shows that 1,303 hours of labor/A at $4.50/hr = $5,414 per acre.
2. Two percent of the acreage would be established on newly cleared (uninfested) land at a preparation cost of $2,000/A plus the purchase cost of land.

Florida (Cut Flowers)

1. One hundred percent of the acreage would require hand-weeding, $5,414 per acre.
2. One percent of the acreage would be established on newly cleared (uninfested) land at a preparation cost of $2,000/A plus the cost of the land.
3. One percent of the acres would be steam sterilized at a cost of $2,500 per acre.

North Carolina

1. One hundred percent of the acres would use hand-weeding at an estimated cost of $6,000 per acre.
2. Five percent of the acreage would use steam sterilization at a cost of $6,400/A for wood fuel (not including equipment).

Remarks submitted by contributors:

1. Other non-chemical alternatives such as biological control, crop rotation, genetic resistance, integrated pest management, irradiation, prevention, solarization, and steam sterilization are not effective or economical as nonchemical alternatives to methyl bromide (Florida Caladiums).
2. "New" land means land in native vegetation. Florida has little new land available. The cost of moving to "new land" has become prohibitive.
3. Vorlex, which is a mixture of halogenated hydrocarbons and isothiocyanate, has environmental concerns that are unresolved.
4. The use of alternatives to methyl bromide will have several impacts which must be considered.

    a) Less weed control will result and require more hand-weeding.
    b) Plant stands will be reduced because of inconsistent performance of alternative pesticides.
    c) Residue management (i.e. aeration time after fumigating) will be longer and require bioassay to determine dissipation.
    d) Under wet and cool conditions aeration will be much delayed, causing non-uniformity and reduced value of plants.
    e) The overall effects could be expected to reduce saleable plants per acre by 30-50 percent.

f) Steam sterilization was once the mainstay of the flower industry, but was replaced by methyl bromide. Steam is generally not as effective as methyl bromide for weed or nematode control. Steam is a very expensive alternative; extremely slow (equipment moves in feet per hour); dangerous to personnel; and the necessary equipment is difficult to obtain. Cost per acre is probably in excess of $2,500. Return to steam sterilization would decrease the acreage because the land could not be sterilized fast enough. Cost is heavily dependent upon the price of petroleum products. Worker safety is also a concern with steam sterilization.

PEACHES
(California)

Peach data reported by California is shown in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Ninety percent of presently treated orchard would be treated with metam-sodium at a cost of $525 per acre.
2. Five percent would be treated with other non-fumigant nematicides at various costs and with various responses.
3. Five percent of the acreage would be planted with no treatment and could go out of production.

Alternative Scenario A.

1. Chloropicrin would probably be applied to 100 percent of the acreage at a cost of $1,200/A, followed by use of metam-sodium on roughly 10 percent of selected acreage at a cost of $700 per acre.

2. Nemacur might be considered for application through existing drip systems or by banding followed with irrigation. Nemacur applied three times/season would cost $199.50/A and would be considered a maintenance treatment that does not reduce nematode populations.

Scenario B: No fumigants available.

1. Forty percent of currently treated land would be allowed to lie fallow for four years with 100 percent loss of production in order to diminish infestations.
2. Five percent would plant even though no pesticide is available. This land would possibly go out of business.
3. Fifty-five percent of the acreage would not be planted with a resulting loss of all production on these acres.

Table 7. The use of soil-applied methyl bromide on ornamental/nursery plants, 1989-90 (avg.). Note: Losses expressed as average wholesale value before containerization.

State	Production Acres	Production Total Plants	Acres Treated	Application Rate (lb/A)	Treatment Cost Including Application ($/A)	Yield Loss W/O CH_3Br ($)[1]	Yield Loss W/O Fumigants ($)[1]
California	50,000	2.1 billion	6,204	400	1,150	130,749,300	605,319,440
Florida[3]	1,000	18 million[2,5]	750	435	1,100	5,062,500 the first year and 10,125,000 the second year. Non-chemical alternatives. Move to new land and hand labor.	
Florida[4]	782 (273 under saran)	13.3 million	743	400	$15 for fields $2,000 for saran	5.320 million first year, 6.65 million in second year including value of 10% of lost acreage. Without Vorlex as an alternative, 9.38 million in the first year, 10.032 million in the second year including value of 10% of lost acreage. Without fumigants = 10,772,129.	
North Carolina	1,500	22.5 million	1,350	450	1,160	9,000,000	9,000,000 + labor cost.
South Carolina	Reported no use of methyl bromide.						

[1]Losses necessitated conversion to financial expression.
[2]NAPIAP placed arbitrary value of .75 each seedling after survey of industry.
[3]Data developed for Caladiums variety only.
[4]Cut flowers.
[5]NAPIAP estimate of 18,000 plants per acre.

Remarks submitted by contributors:

On a peach tree short life (PTSL) site in Georgia[4], preplant soil fumigation with methyl bromide decreased nematode population densities and tree loss due to PTSL and increased trunk circumference and tree vigor. Soil fumigation interacted with both rootstock and pruning date, and the effects of the treatments were additive. December-pruned trees on Nemaguard rootstock without fumigation resulted in the greatest number of weak, poorly growing trees as well as dead trees. When soil was preplant-fumigated, either Lovell or Nemaguard rootstock could be used and time of pruning had less effect. Fumigation also decreased the number of trees with trunk injury caused by cold temperature. Development of cold damage was greater on Nemaguard than on Lovell rootstock, and with December than with March pruning. Evidence of weakness and poor vigor was often an indication of susceptibility to PTSL.

PEPPERS
(California, Florida, Georgia,
North Carolina, South Carolina)

Peppers are a high value crop with a high potential for yield and economic return on investment. Peppers are susceptible to pests, and also to pesticide injury when applied over the foliage and fruit of the plants. The availability of a reliable preplant soil fumigant, such as methyl bromide, has been a critical factor in establishing the pepper growing industry in producing States. The magnitude of losses estimated without methyl bromide is shown in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

California

Ten percent of the acreage will be placed in rotation for three to five years. Because carrots are double-cropped on peppers, this will entail a loss of all peppers and carrot production on these acres for three to five years.

Florida

1. Eighty percent of the acres will be treated with Vorlex at a cost of $395 per acre.
2. Twenty percent of the acres will be treated with metam-sodium at a cost of $265.00 per acre.

Georgia

1. Fifty percent of the acres will be treated with metam-sodium at a cost of $700 per acre.
2. Ten percent of the acres will be treated with Vorlex at a cost of $550 per acre.

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[4]Sharpe, R.R., Reilly, C.C., Nyczepir, A.P., and Okie, W.R. 1989. Establishment of peach in a replant site as affected by soil fumigation, rootstock, and pruning date. Plant disease 73:412-415.

3. One hundred percent of these same acres will be treated with Terrachlor (PCNB) at a cost of $18 per acre.

North Carolina

1. Fifty percent of the acres will be treated with metam-sodium at a cost of $700/A, but will lose 50 percent of production.
2. Ten percent of the acres will be treated with Vorlex at a cost of $550/A, and will also lose 50 percent of production.

Scenario B: No fumigants available.

California

One hundred percent of the acres will be rotated for three to five years with a 100 percent loss of production for that period of time.

Florida

Two percent of the acres will be relocated to "new land" at a preparation cost of $2,000/A plus the cost of land acquisition.

Georgia

One hundred percent of the crop would require rotation with the intent of finding infestation-free land.

North Carolina

One hundred percent of the acres would need to be rotated to newly cleared land at a cost of about $1,000/A for clearing land.

Remarks submitted by contributors:

1. Methyl bromide is a part of the full-bed plastic mulch system for pepper production.
2. A minimum loss in production of 20 percent will occur when using Vorlex, and a minimum loss of 50 percent will occur when using metam-sodium.
3. Other nonchemical alternatives such as biological control, crop rotation, genetic resistance, integrated pest management, irradiation, prevention, solarization, and steam sterilization are not effective or economical as alternatives to methyl bromide.
4. "New" land means land in native vegetation. Florida has little "new" land available. The cost of moving to "new" land has become prohibitive.
5. Nonchemical alternatives are not acceptable options.
6. Methyl bromide and irrigation water are introduced using a "trickle tube" under the plastic.
7. Cucumbers are commonly double-cropped after peppers.

PLUMS/PRUNES
(California)

Because of the obvious interrelationship between plums and prunes and the similarities in cultivation practices, these commodities were combined for this benefits assessment study. These fruits represent a large portion of production acreage in California as shown in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Ninety percent of the acreage will be treated with metam-sodium at a cost of $525 per acre.
2. Five percent will be treated with multiple treatments of nematicides with unpredictable results.
3. Five percent will plant without pesticide treatments and could go out of production.

Scenario B: No fumigants available.

1. Forty percent of acreage will be allowed to lie fallow and sustain 100 percent loss of production for four years.
2. Five percent of acres will be planted without use of pesticides and will could go out of production.
3. Fifty-five percent of the acreage will not be planted, with total loss of production.

STRAWBERRIES
(California, Florida,
North Carolina, South Carolina)

Strawberries have the potential to sustain serious production losses without preplant soil fumigation. State specialists indicate that chemical alternatives to methyl bromide are grossly inadequate and that satisfactory nonchemical alternatives are nonexistent. Strawberry production will immediately reflect the loss of proper preplant soil treatment. Potential losses in strawberries is shown in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

California

1. Ten percent of the acres will be treated with metam-sodium at a cost of $700 per acre.
2. Ninety percent of the acres will be treated with chloropicrin at $1,200 per acre.

Florida

1. Sixty-five percent of the acres will be treated with Vorlex at a cost of $397/A, but with a 35 percent loss in yield.
2. Twenty-five percent of the acres will be treated with metam-sodium at a cost of $265/A but at a 50 percent loss in yield.

North Carolina

It is possible that some (percent not known) of the acres would be treated with solarization at an average cost of $450 per acre. This is still an experimental and undeveloped approach.

South Carolina

There are no alternatives for methyl bromide.

Scenario B: No fumigants available.

California

No nonchemical controls are available.

Florida

Two percent of the acres will be relocated to new land at a cost of $2,000/A for land preparation, plus the cost of land acquisition.

North Carolina

No suitable nonchemical control exists except for solarization, which costs $450 per acre.

South Carolina

There are no acceptable alternatives.

Remarks submitted by contributors:

1. Metam-sodium does not disperse well in the soil and requires water (rain or sprinkler irrigation) for good movement. The poor dispersion reduces the utility of this product and limits its consistency of control. Chloropicrin is an excellent fungicide, but generally a poor nematicide and herbicide.
2. There are no nonchemical alternatives that can be used on acreage currently treated with methyl bromide. Two alternatives: soil solarization and crop rotation have been studied and both are impractical in the coastal areas where strawberries are grown.
3. Other nonchemical alternatives such as biological control, genetic resistance, integrated pest management, irradiation, prevention, and steam sterilization are not effective or economical as nonchemical alternatives to methyl bromide.
4. Vapam (metam-sodium) moves very little in soil except by water. Fails in 40-60 percent of treatments.
5. "New" land means land in native vegetation. Florida has little"new" land available. The cost of moving to "new" land has become cost-prohibitive.

6. Neither Vorlex nor Vapam control black root rot well, and in situations where this is a problem and growers do not have the acreage to rotate, they will have to stop growing strawberries.
7. To replant strawberries into strawberry soil, methyl bromide plus chloropicrin is used to control disease and minimize weed problems.
8. In California, the use of methyl bromide and chloropicrin soil fumigation resulted in huge increases in yield and quality in several crops. This combination is widely credited with saving the strawberry industry from high production cost and foreign competition.[5]
9. Soil fumigation with mixtures of methyl bromide and chloropicrin has been an integral part of strawberry cultivation in California since about 1960...The impact of soil fumigation in California is reflected in the common reference to the distinct eras 'before fumigation' and 'after fumigation' among growers who remember the difficulties and frustrations of strawberry cultivation before the introduction of the soil treatments.[6]

   Benefits of soil fumigation with methyl bromide:

   - growth enhancement
   - conservation of applied nitrogen
   - improved nutrient uptake
   - weed control

SWEET POTATOES
(California)

Sweet potatoes are extremely vulnerable to soil pests. A significant yield loss occurs without the availability of methyl bromide as shown in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Ten percent of the treated acres will be rotated with a loss of all production for one year.
2. Ninety percent of treated acres will receive metam-sodium at a cost of $525 per acre.

Scenario B: No fumigants available.

1. Ten percent of the treated acres will be rotated with a total loss of production for one year.
2. Remaining acres would sustain extreme losses.

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[5]Committee on the role of alternative farming methods in modern production agriculture. 1989. Research and Science in Alternative Agriculture, National Research Council, National Acad. Press, Washington, DC.

[6]Wilhelm, S. and A.O. Paulus. 1980. How soil fumigation benefits the California strawberry industry. Plant Diseases 64:2564-2570.

Remarks submitted by contributors:

1. There is no other proven treatment except Telone II; however, that product has been removed from use in California.
2. There is not enough available land to rotate or leave fallow.

TOBACCO PLANT BEDS
(Georgia, Kentucky,
North Carolina, South Carolina)

Tobacco plant beds are maintained by nurseries for commercial supply of plants to tobacco growers, or plant beds may be established by tobacco growers to provide a source of their own transplants. Plants from beds that have not been properly treated with preplant fumigants may not reflect a reduction in the number of transplants. However, non-fumigated plants often have reduced vitality or carry a pest organism with them to the field, which can result in poorer quality tobacco and reduced tobacco income. For that reason, the data in Table 5 reflect production and yield loss as tons of cured leaf tobacco.

Scenario A: Methyl bromide canceled, other fumigants available.

Georgia

1. Thirty percent of the acres in plant beds will be treated with Basamid (dazomet) at a cost of $2,672/A in plant beds (or $442/A in field transplanted tobacco).
2. Twenty percent of the acres in plant beds will be treated with metam-sodium at a cost of $1,906/A in plant beds (or $31.50/A in field transplants).
3. Ten percent of the acres in plant beds will be treated with Vorlex at a cost of $2,447/A in plant beds (or $40.45/A in field transplants).
4. Forty percent of the acreage in plant beds will be diverted to greenhouse plant beds which will cost $1,929.50/A plant bed (or $170/A of transplanted tobacco).

Kentucky

1. Eighty percent of the acres, of plant beds will be treated with Vorlex at a cost of $1,000 per acre.
2. Twenty percent of the acres of plant beds will be treated with metam-sodium at a cost of $1,000 per acre.

North Carolina

1. Seventy percent of the acres of plant beds will be abandoned in order to build and adopt greenhouses. This would cost $1,921 per acre.
2. Twenty-eight percent of the acres of plant beds will be treated with Basamid (dazomet) at a cost of $1,832 per acre.

South Carolina

Some plant-bed acres will be treated with metam-sodium, Vorlex, Basamid (dazomet), and a portion will be established in greenhouses.

Scenario B: No fumigants available.

Georgia

1. Ten percent of the acres will be treated by flame heat. No cost estimate provided.
2. Twenty percent of the acres will be treated with unidentified insecticides. No cost estimates provided.
3. Fifteen percent of the acres would be treated with unidentified herbicides. No cost estimates were provided.
4. Fifty percent of the acres will be abandoned and transferred to greenhouses at a cost of $1,929 per acre.

Kentucky

1. Burning of beds might be considered, but it is prohibited by law and local ordinances. It will cost $1,500 per acre.
2. One hundred percent of the acres will be rotated to "new sites." No estimate of site preparation or land acquisition costs was provided.

North Carolina

1. Ninety percent of the acres will be forced to abandon sites and build greenhouses. Estimated cost is $1,920 per acre.
2. Ten percent of acres of plant bed equivalent will be obtained from commercial greenhouses at a cost of $2,710 per acre.

South Carolina

One hundred percent of the acres will abandon sites and build greenhouses. No cost estimate provided.

Remarks submitted by contributors:

1. Growers do not have the appropriate needed herbicides for tobacco plant beds.
2. There are no effective substitutes (alternatives) for methyl bromide on tobacco.
3. Accumulated pest effects can easily cause a 50 percent reduction in yield. Many growers use only hand-operated fumigation (1-1.5 lb cans of methyl bromide). It would be difficult for growers to operate without methyl bromide, unless small bed size fumigants are made available.
4. A chemical alternative requires a three to five times longer waiting period, which could contribute to increased crop injury.
5. Efficacy of chemical alternatives are highly variable.
6. Alternatives result in a 60 percent increased production cost of transplants.

TOMATOES

(California, Florida, Georgia,
North Carolina, South Carolina)

Tomato production is strongly dependent on methyl bromide because of the important role that it plays and this crop's reliance on plastic mulch. Tomatoes grown in the absence of proper pre-plant soil treatment succumb quickly to soil borne pests. These points are illustrated in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

<u>California</u>

Ten percent of the acres will be planted to a rotation crop for one year with a lack of all tomato production for that year.

<u>Florida</u>

1. Eighty percent of the acres will be treated with Vorlex at a cost of $397 per acre.
2. Twenty percent of the acreage will be taken out of production due to increased production costs.

<u>Georgia</u>

1. Fifty percent of the acres will be treated with metam-sodium at a cost of $700 per acre.
2. Ten percent of the acres will be treated with Vorlex at a cost of $550 per acre.

<u>North Carolina</u>

1. Fifty percent of the acres will be treated with metam-sodium at a cost of $700/A. These acres will sustain a fifty percent loss in production.
2. Ten percent of the acres will be treated with Vorlex at a cost of $555/A and will sustain a fifty percent loss in production.

<u>South Carolina</u>

1. Twenty percent of the acres will be treated with chloropicrin. No cost estimate.
2. Twenty-five percent of the acres will be treated with Vorlex. No cost estimate.
3. Thirty percent of the acres will be treated with metam-sodium. No cost estimate.

Scenario B: No fumigants available.

<u>California</u>

Ten percent of the acreage will be rotated for one year, with a complete lack of production for that year.

Florida

Two percent of the acres will move to "new land" at a cost of $2,000/A for land preparation, plus the cost of land acquisition.

Georgia

One hundred percent of the acreage will be rotated on a regular basis. No cost estimate provided.

North Carolina

One hundred percent of the acreage would be rotated to newly cleared land at a cost of $1,000/A for clearing plus any cost of acquisition.

South Carolina

No alternative nonchemical control methods exist.

Remarks submitted by contributors:

1. Methyl bromide is a significant part of the full-bed plastic mulch system for tomato production.
2. Other nonchemical alternatives such as biological control, crop rotation, genetic resistance, integrated pest management, irradiation, prevention, solarization, and steam sterilization are not effective or economical as nonchemical alternatives to methyl bromide.
3. "New" land means land in native vegetation. Florida has little "new" land available. The cost of moving to "new" land has become prohibitive.
4. Non-chemical alternatives are not acceptable options.
5. Twenty percent of the tomato acreage treated with Vorlex would be lost in the first year due to increased production costs and up to 80 percent of the tomato acreage would be lost by the fifth year.
6. Losses would progressively increase in subsequent years. Treatment with metam-sodium and Vorlex during protracted cool, wet springs would not be possible as inadequate time would be available to allow for proper fumigation with these alternatives, which require about 2-4 weeks aeration period. This could be a critical consideration, as timing of planting to market is a very critical step. Cold, wet soils would prohibit earlier application in the spring.

WALNUTS
(California)

Walnuts are produced commercially in several States; however, California is the major producing State. Walnut production is strongly dependent on the availability of methyl bromide for replanting trees as demonstrated in Table 5.

Scenario A: Methyl bromide canceled, other fumigants available.

1. Five percent will be allowed to lie fallow to allow infestations to recede, but with 100 percent lack of production for four years.
2. Eighty-five percent will be treated with metam-sodium at a cost of $525 per acre.
3. Five percent of the acres will receive multiple treatments of nematicides, with unpredictable results.
4. Five percent of the acres will be planted with no pesticides, and could go out of production.

Scenario B: No fumigants available.

1. Twenty percent will be allowed to lie fallow for four years with 100 percent total lack of production.
2. Five percent of the acres will be planted without the use of pesticides. These could go out of production.
3. Seventy-five percent of the acreage will not be planted, thereby sustaining a 100 percent lack of production on these acres.

Remarks submitted by contributors: There are no known or economically feasible chemical or nonchemical alternatives.

USE OF METHYL BROMIDE FOR POST HARVEST FUMIGATION OF CITRUS IN FLORIDA

State and industrial specialists concluded that methyl bromide application for the replanting (reset) of trees in citrus production orchards represented negligible use. Although this practice occurs, preplant fumigation does not warrant consideration in this study. The most important citrus use of methyl bromide is in postharvest fumigation (Table 8). The data does not reflect import/export applications.

Remarks submitted by contributors:

1. Fumigation is performed by Florida Department of Agriculture and Consumer Services on behalf of fresh citrus packers for transport to other citrus-producing States.
2. Fly-free protocol: A portion of Florida citrus is grown in areas considered free of Caribbean fruit fly. Methyl bromide-treated fruit comes from areas that do not qualify as fly-free.
3. Yield loss as such does not occur when methyl bromide is not used. However, diversion of the fruit to non-premium processing and culling would result in the losses shown in Table 8.

Table 8. The use of methyl bromide on post harvest fumigation of trucked citrus in Florida, 1989-90 (avg.).

Tons Treated With CH_3Br	Application Rate (lb/Truck)	Treatment Cost Including Application ($/Truck)	Yield Loss W/O CH_3Br (Tons)	Yield Loss W/O Fumigants (Tons)
79,571 or 4,080 trucks	25 lb/19.8 Tons (truck)	120	Fresh market loss of 76,000 tons with a value of $25 million.	Fresh market loss of 76,000 tons with a value of $25 million.

THE ECONOMIC EFFECTS OF BANNING METHYL BROMIDE FOR SOIL FUMIGATION

Introduction

In this analysis, the short-term economic implications are derived for use of alternatives to methyl bromide in the production of 21 crops grown in California, Florida, Georgia, North Carolina, and South Carolina, based upon the biological assessment. It should be emphasized that the derived economic effects are based on 1991/92 crop year estimates of available methyl bromide alternatives, treated acres, and production losses that could change with atypical changes in weather, pest population outbreaks, loss of available alternatives, or new nonchemical and chemical pest control strategies.

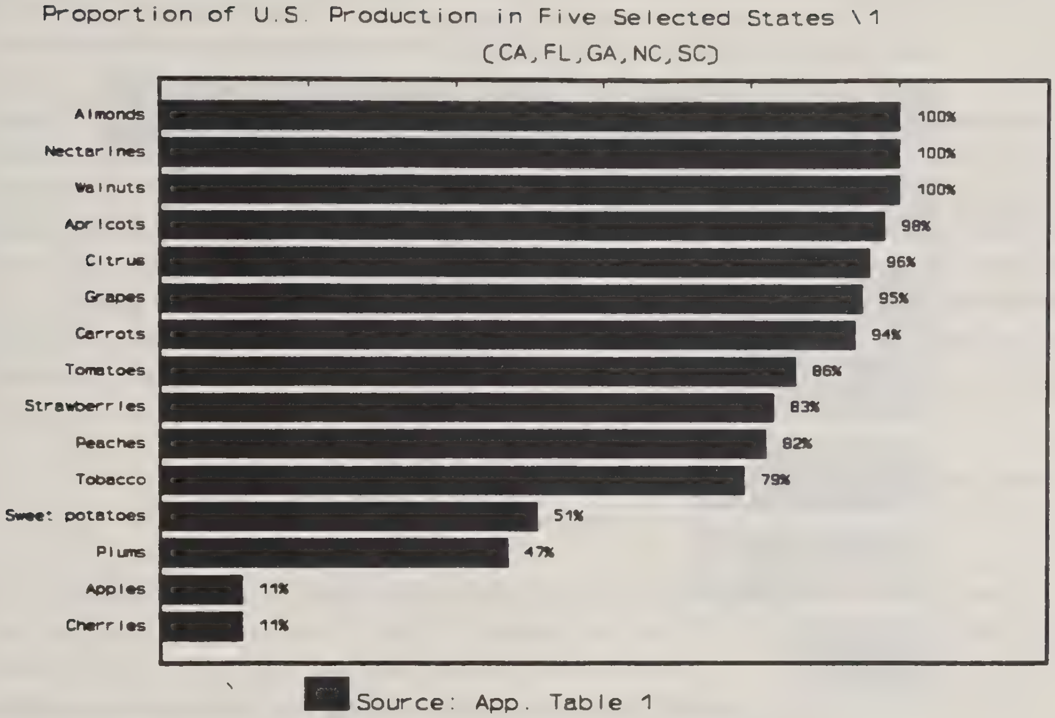
Scope of Economic Effects

Although the methyl bromide-ban assessment is limited to 21 crops produced in five States, the price effects of generally reduced yields impact all consumers as well as growers in other States. The five-State study area for the 10 fruit and nut crops produces from 100 percent of the U.S. almond, nectarine, and walnut crops to 11 percent of the apple and cherry crops (Figure 1). For four of the eight vegetable crops for which total U.S. data are available, the area for economic analysis represents a major proportion of the selected crops--carrots (94 percent), strawberries (83 percent), sweet potatoes (51 percent), and fresh market tomatoes (86 percent). For tobacco only, Kentucky is added to represent a six-State study area total of 79 percent of the U.S. tobacco crop. Additionally, the analysis examines the economic effects of losing Vorlex as an alternative to methyl bromide due to the voluntary cancellation of the Vorlex registration. The crops where this applies include melons, ornamentals, peppers, strawberries, tobacco, and tomatoes.

The economic analysis is limited to a short-term analysis of the first year of a ban, and thus does not take into account the multiple-year strategies of crop rotations, allowing land to lie fallow, construction of greenhouses, and other longer term scenario alternatives and strategies considered in the biological analysis. However, when large price effects are estimated, the analysis considers the potential for imports to offset production losses and moderate price increases in the longer-term and their economic implications for growers and consumers.

The analysis of a methyl bromide ban assumes the immediate cancellation or suspension of all registered crop uses. Under the Clean Air Act, production and use of methyl bromide would be phased out by the year 2,000. Such a phase-out would defer the economic loss of banning methyl bromide. A phase-out could allow time for new chemical or nonchemical controls to be developed and adopted by growers to replace current methyl bromide uses. If effective replacement controls were found, there would be considerably less impact on crop prices and associated consumption cost than is indicated in this assessment. However, there is no guarantee that effective alternatives to methyl bromide will be found. During a phase-out, price increases could be further dampened by increased production in other States where methyl bromide is not needed, or by imports from countries not affected by the phase-out. Smaller price increases would mean smaller increases in grower revenue and consumer cost than is indicated in this analysis.

Figure 1



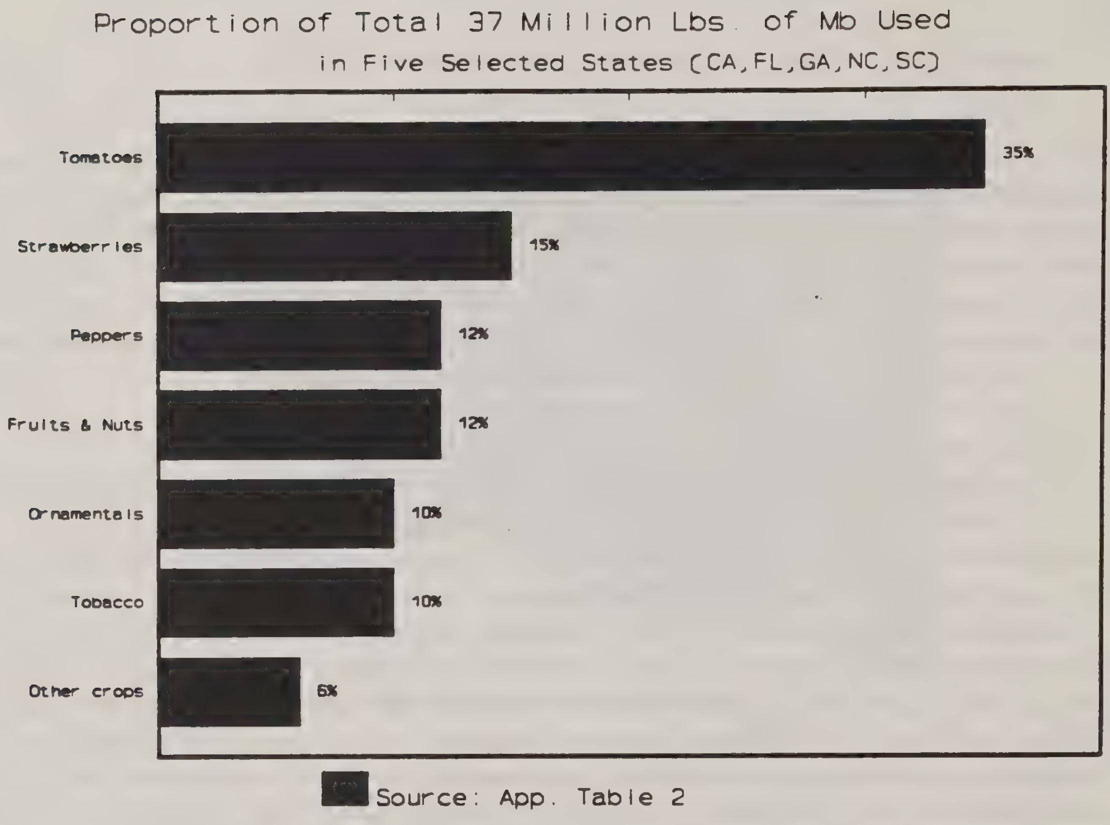
\1 Data not available for cucumbers, eggplants, melons, ornamentals, peppers, and forest seedlings. Tobacco data include Kentucky's production.

Methyl Bromide Use and Available Chemical Alternatives

Industry sources indicate an estimated 64 million pounds of methyl bromide was used in 1990 in the United States. Uses included postharvest food/crops (5 mil.lbs.), structures (4 mil.lbs.), chemical intermediate manufacturing (6 mil.lbs.), and preplant soil fumigation (49 mil.lbs.). According to the 1991-92 biological assessment, an estimated 37.9 million pounds of methyl bromide was used in 1991 to treat 155,091 acres on the 21 crops in the five-State study area. Four of the 21 crops accounted for 71 percent of the total 37 million pounds: tomatoes (35 percent), strawberries (15 percent), peppers (12 percent), and tobacco (10 percent) (Figure 2). Rate of use averaged 242 lbs./acre for the 21 crops, ranging from 428 lbs./acre for tobacco plant beds to 123 lbs./acre for melon crops (App. A, Table 2).

With a methyl bromide ban, biologists indicate that metam-sodium could be the major feasible chemical alternative for most of the fruits, nuts, vegetables, and tobacco in the five-State study area. Vorlex (methyl isothiocyanate + 1,3-D) and chloropicrin were considered by biologists as alternatives that also could be used for some vegetables. The registered uses of dazomet are limited to nonfood items. For tobacco plant beds, biologists listed dazomet, metam-sodium, and Vorlex as methyl bromide alternatives. Since the manufacturer of Vorlex will not be seeking reregistration, Vorlex will not be available in the near future for use in producing vegetables, field crops, ornamentals, nursery stock, and plant bed seedlings (7). Additional production losses and cost changes were estimated assuming that Vorlex would not be an alternative on methyl bromide-treated acres. The economic implications of those changes were estimated. With the exception of California, the use of alternative chemical fumigant 1,3-D will continue.

Figure 2



Assumptions

The estimated production costs and price effects assume that the grower will use alternative chemical fumigants that are higher in cost for some crops and generally less effective. The change in cost using the alternative fumigants prior to planting does not include any later additional treatments during the growing season of fungicides, nematicides, insecticides, and herbicides that growers may use in attempting to maintain production at prior levels. Further, the analysis does not take into account the cost and price effects of individual growers planting increased acreage in attempting to maintain prior production levels. Thus, these simplifying assumptions imply that the change in costs involves only alternative fumigants and the price effects assume the same number of acres will be planted after a methyl bromide ban.

In the following sections, the effects of a methyl bromide ban on grower net revenue and consumer cost are indicated for 15 of the 21 study crops. National data on acres, production, and price elasticities were not available to project changes in consumer cost for six crops--cucumbers, eggplants, peppers, melons, ornamentals, and forest seedlings. For these six crops, constant market prices are used to approximate values of production losses.

The analysis of implications of imports on prices and revenues focuses on strawberries, tomatoes, and tobacco. Increased imports would moderate price increases, reduce consumer losses, and increase producer financial losses. These three crops would have the largest proportional production losses among the 15 crops for which price changes were estimated. However, imports of other crops could also increase and result in changes of price, consumer, and producer effects similar to those of these three crops, but of a smaller magnitude. The assumptions create a worst case scenario for U.S. producers, because imports are assumed to increase in response to higher prices while U.S. production is not. U.S. planted acreage and production of these crops could increase, which would

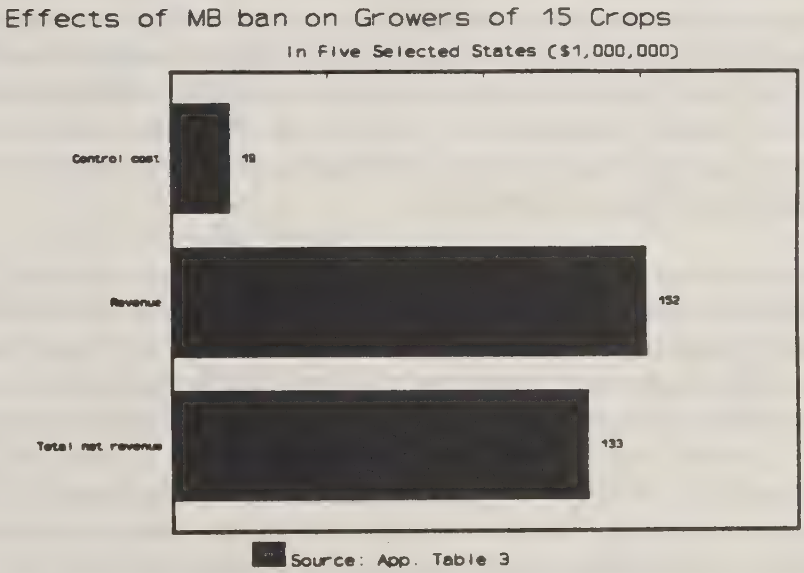
reduce economic losses to producers and consumers. However, the resulting economic loss would be underestimated. The reason is that acreage and production of crops previously grown on those acres would decrease, and economic losses caused by effects on prices, consumers, and producers of those crops are difficult to enumerate.

After discussions with commodity experts in the Economic Research Service, it was assumed that 70 percent of tomato production losses, 90 percent of tobacco production losses, and 15 percent of strawberry production losses would be replaced by imports. For tomatoes, most losses would occur in Florida. Mexico produces tomatoes during many of the same months as Florida and could increase production and divert domestic production to the U.S. market. For tobacco, it was assumed that imports from a variety of countries could replace production losses, because imports are currently increasing. For strawberries, imports currently provide a small portion of domestic consumption, and there is no exporter whose increased shipments to the U.S. could replace a large portion of the production losses.

Grower Impact

To assess the economic effects of using methyl bromide alternatives on growers' net revenues, national estimates are used to project prices of a methyl bromide ban on 15 crops--almonds, apples, apricots, cherries, citrus, grapes, nectarines, peaches, plums/prunes, walnuts, carrots, strawberries, sweet potatoes, tomatoes, and tobacco. If growers use the available alternatives for these 15 crops, the short-term price effects of reduced production would offset a $19 million increase in control costs, resulting in an estimated $133 million total gain in net revenue (Figure 3). The change in net revenue would range from a $103 million gain to tobacco growers to a $31 million loss to strawberry growers (App. A, Table 3a). The control cost impacts include an increase in cost of $15 million for tomato (fresh market) growers with minimal decreases in cost for the fruit and nut crops. The above estimates of changes in grower revenue do not include the impact of a methyl bromide ban on cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings. The price effects of production losses for these six crops could not be estimated because national estimates of acres grown and production are not available.

Figure 3



The large price increases for strawberries, tomatoes, and tobacco would likely encourage longer-term increases in imports that would, in turn, moderate the price increases. Based on the assumed import responses for those commodities, there would be an annual $225 million loss in net revenue for the 15 crops for which price changes were computed. Losses would be about $86 million for tomatoes, $98 million for tobacco, and $4 million for strawberries.

Biologists indicated vegetable growers in some States would experience extreme crop losses of up to 100 percent of the crop using the methyl bromide alternatives (App. A, Table 10a)--strawberries (California 14 percent), cucumbers (Florida 100 percent), eggplants (Florida 100 percent), peppers (Florida 85 percent), strawberries (Florida 59 percent), and fresh market tomatoes (Florida 19 percent, Georgia 45 percent, North Carolina 81 percent, and South Carolina 31 percent).

Without Vorlex as an alternative, production losses caused by a methyl bromide ban would increase, particularly on peppers and tomatoes grown in Florida (App. A, Table 10b). About 46 percent of Florida fresh market tomato production would be lost without methyl bromide and Vorlex. In the short-run, net revenues on the 15 crops for which price changes were estimated would increase by $153 million per year (App. A, Table 3b). In the longer-run, assuming increases in imports, net revenue would decrease by $322 million per year. This net revenue loss would be about $100 million per year more than if Vorlex were available, and tomato producers would bear most of that additional loss.

For the individual grower, the effectiveness and cost of methyl bromide alternatives and extent of methyl bromide-treated acres may determine whether the grower continues to produce a crop. Individual growers may continue to produce a crop affected by the ban as long as the grower can cover cost of seed, fertilizer, pesticide, and other variable costs. However, if the grower's revenue does not cover cost of equipment, land, and other fixed costs, the grower will likely discontinue production of that crop.

Consumer Impact

The short-term price effects and reduced production of the 15 crops would cost consumers an estimated $559 million, which includes commodities exported as well as those consumed domestically (App. A, Table 3a). In the longer-run after imports increase and price rises moderate, annual consumer losses would decline to $189 million. Without Vorlex as an alternative to methyl bromide, annual consumer losses would be $782 million in the short-term, but would decline to $269 million in the longer-run (App. A, Table 3b).

For fruit and nut crops, methyl bromide-treated acres and associated production generally accounts for a relatively small proportion of the total crop acres. As a result, the minor losses in production (1 percent or less) have negligible impacts on price (App. A, Table 11a). The total short-term increase in consumption cost is estimated at $31 million, ranging from a $18.6 million increase in the cost of citrus to less than a $0.5 million increase in the cost of apricots and cherries.

For vegetables, biologists suggest the lack of feasible alternatives to methyl bromide may result in other crops replacing Florida cucumber and eggplant production in the first year of a ban. Consumers of fresh market tomatoes and strawberries would lose $225 million and $76 million, respectively (Appendix A, Table 3a). The likely short-term effects of the higher prices of affected crops would increase the demand and prices of substitute fruits and vegetables. In the longer-run, annual consumer losses for fresh market tomatoes and strawberries would decline to $70 million and $65 million, respectively. Without Vorlex as an alternative to methyl bromide, annual consumer losses would be $443 million and $79 million for tomatoes and strawberries, respectively, in the short-run and $147 million and $68 million in the longer-run (App. A, Table 3b).

For tobacco, the use of methyl bromide alternatives would increase costs to consumers by an estimated $228 million. In the longer-run, losses to tobacco consumers would decline to $23 million per year. Without Vorlex as an alternative, consumer losses would be $230 million per year in the short-run and $23 million in the longer-run (App. A, Table 3b).

In the following section, an explanation is provided as to why specific impacts to growers and consumers are not derived when data limitations prevent use of projected prices.

Evaluation of Production Losses Using Constant Prices

In deriving the impact of a change in production, use of a "projected price" involves estimating the change in price associated with a change in production, e.g., a drop in production generally results in a higher crop price. If national estimates of production, acres planted, demand elasticities, etc. are not available to project the new price with a loss in production, the use of a "constant market price" is sometimes used to reflect the value of the total economic loss. Use of a constant price simply involves multiplying the average market price times the loss in production.

A pesticide ban generally results in higher prices in response to reduced production from less efficient control. The use of constant prices to value crop loss, as compared with higher projected crop prices, understates the banned pesticide-user's loss in revenue, and ignores the increases in nonuser revenue and consumer cost. Conversely, the use of projected higher prices associated with lower production, generally raises "all growers" revenues (e.g., methyl bromide-users and nonusers) and increases consumption cost. For example, use of projected instead of constant price would increase the value of production loss (using methyl bromide alternatives) of tomatoes and strawberries by an estimated 22 percent and 14 percent, respectively (App. A, Table 11a). Thus, the difference in projected versus constant price would offset the effect of lower production on revenue from treated acres, add to the revenue from untreated acres, and increase the cost of consumption.

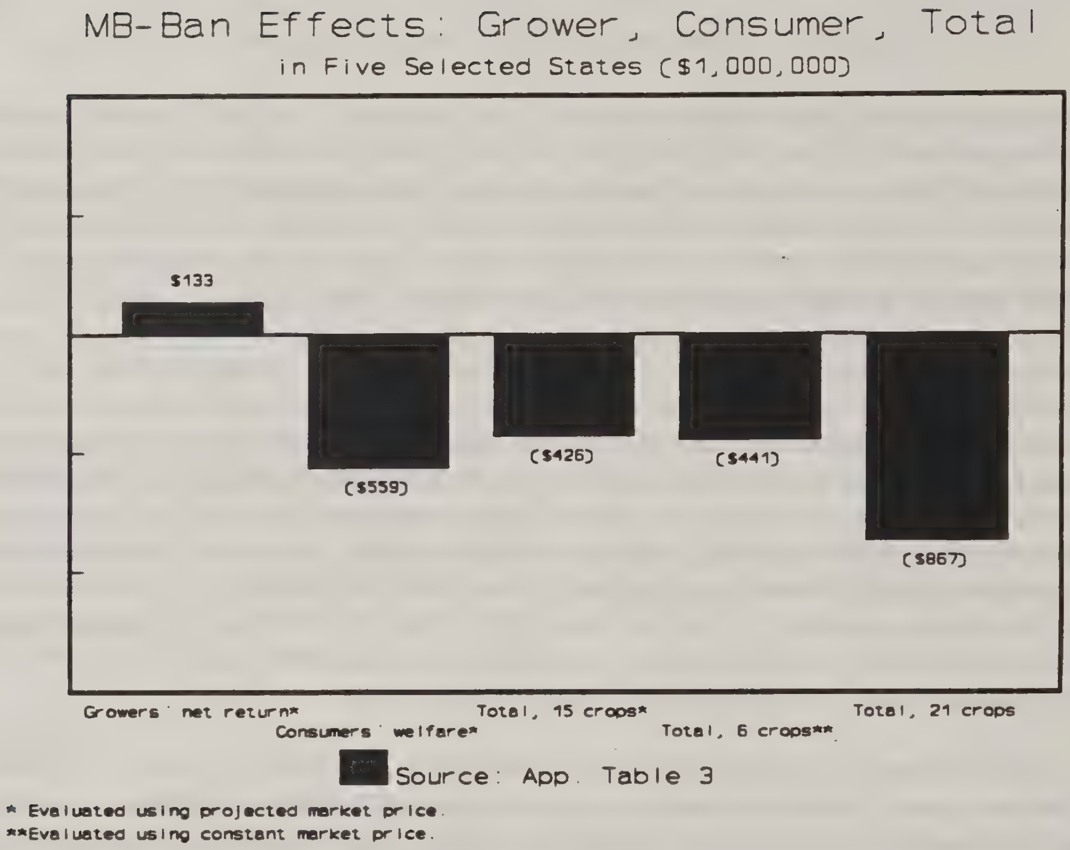
If there is a minor difference between the projected and constant price (eg., 1 percent or less), the difference in the derived "total effect" (producer plus consumer effects) may be minor. As data limitations prevent calculation of projected prices, the differences in projected and constant prices are not known. However, the total effect of a methyl bromide ban on each of the six crops is derived as a "rough measure" in absence of other available measures.

Total Economic Impact

The total short-term loss of a methyl bromide ban is an estimated $867 million, which includes an increase in net returns (change in revenue minus change in cost) and increase in commodity cost to consumers (or welfare loss). (Figure 4). For 15 of the 21 crops, the sum includes a projected $133 million increase in growers' net revenue, and a $559 million cost to consumers. The $867 million loss includes a $442 million loss due to production losses for cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings. The total economic loss for these crops were estimated as the sum of production loss assuming constant prices, and the change in pest control costs. The value of the estimated production loss of the six crops, using methyl bromide alternatives, is estimated at $426 million (App. A, Table 3a, footnote \a). In the longer run when imports have increased and price rises moderated, the total loss from soil uses would decline slightly to $856 million per year. However, the annual consumer and producer impacts for the 15 crops for which price changes were estimated would change dramatically: a $225 million <u>loss</u> for producers and a $189 million loss for consumers.

The voluntary cancellation of Vorlex would dramatically increase the impact of a methyl bromide ban (App. A, Table 3b). In the short-run, the total annual loss would increase by $214 million (25 percent) to $1.08 billion per year. Of the additional loss, $197 million (92 percent) is attributed to fresh market tomatoes. For the 15 crops for which price changes were estimated, consumer losses would be $782 million per year, while net revenue increased $153 million per year. For the other six

Figure 4



crops, the total annual loss would increase by $11 million to $453 million. In the longer-run after increased imports moderate price rises, the total annual loss is estimated to be $1.044 billion, a decline of $38 million from the short-run case. Fresh market tomatoes would contribute $327 million (31 percent) of the annual loss. For the 15 crops for which price increases were estimated, consumer losses would moderate to $269 million per year, but net revenues would decline by $322 million per year.

In the following sections, the major and minor uses of methyl bromide are discussed for 11 of the 21 study crops with highest negative total economic effects (change in grower net revenue plus change in consumer cost).

Major Methyl Bromide Uses

Ornamentals, peppers, strawberries, tobacco, and tomatoes account for an estimated 82 percent of the 37.9 million pounds of active ingredients used for the 21 crops. Banning methyl bromide use on these crops would have an estimated total impact of $100 million or higher per crop. The quantity of methyl bromide used, acres treated, cost of alternatives, estimated production losses, and economic effects are discussed for individual crops in the following sections.

Ornamentals. The ornamental crop category includes methyl bromide treated nursery plant bed and field sites in the production of flowers, shrubs and other nursery plants. As the ornamental category includes a wide range of plant types and varieties, time and data limitations required grouping of various plant types and estimates of constant (instead of projected) dollar valuations of changes in

yield (see biological analysis). An estimated 3.7 million pounds of methyl bromide is used to treat an estimated 12 percent of the 50,000 acres of ornamentals in California, 84 percent of the 1,782 acres in Florida, and 90 percent of the 1,500 acres in North Carolina (App. A, Table 4, 6). In greenhouses, the major alternative to methyl bromide is steam treatment. In the field, alternatives include metam-sodium, dazomet, Vorlex, and hand-weeding. Soil-less planting mixtures are used in South Carolina as an alternative to methyl bromide treatment. Using methyl bromide alternatives, the change in control cost would range from an estimated decrease of $159 per acre in California to an increase of $6,314 per acre in Florida (App. A, Table 7a). Using constant prices, the estimated reduced production of the various crops using the methyl bromide alternatives is valued at $150 million. Without Vorlex, the annual production loss would be valued at $155 million.

Peppers (Bell, Chili, Red, and miscellaneous peppers). An estimated 4.5 million pounds of methyl bromide are used to treat about 21,968 acres of various varieties of peppers in California, Florida, Georgia, and North Carolina (App. A, Table 2,5). Treated acreage ranges from 19,635 or 85 percent of the Florida acres to 594 or 3 percent of the California acres (App. A, Table 6). The change in treatment cost per acre using methyl bromide alternatives ranges from an increase of $191 per acre in Florida to a decrease of $161 per acre in Georgia. No alternatives to methyl bromide were indicated by California biologists. Metam-sodium and Vorlex were indicated as potential alternatives to methyl bromide in Florida, Georgia, and North Carolina. Production losses using the indicated alternatives would range from 85 percent of the crop in Florida to 3 percent in California and North Carolina. Using constant prices, the estimated 223,351 tons of estimated reduced production, using the methyl bromide alternatives, is valued at $127 million (App. A, Tables 3a, 9a). Without Vorlex as an alternative, 235,140 tons of peppers would be lost valued at $134 million annually (App. A, Tables 3b, 9b).

Strawberries. An estimated 5.7 million pounds of methyl bromide is used to treat 89-99 percent of the strawberry acres in California and Florida, and 33 percent of the acres in North Carolina and 67 percent of the acres in South Carolina (App. A, Tables 2,6). The four States account for about 83 percent of the U.S. commercial strawberry production (App. A, Table 1). Using methyl bromide alternatives (metam-sodium, chloropicrin, and Vorlex) would lower production by 104,809 tons in the four States, ranging from an estimated 59 percent loss in Florida production to 12 percent in North Carolina (App. A, Tables 9a,10a).

Use of the methyl bromide alternatives would increase control costs by an estimated $1.1 million (App. A, Table 8a). In response to lower production, the price of strawberries is projected to increase by 14 percent, with an associated decrease in growers' net revenue of $31 million and increase consumers' cost by $76 million. A ban of methyl bromide use on strawberries would result in an estimated loss of $107 million. In the longer-run, imports would change the total economic impact little. Prices would increase by 12 percent, net revenue would decline by $41 million per year, and consumers would lose $65 million per year.

Without Vorlex as an alternative, strawberry production loss is estimated to be 109,652 tons, and the total annual economic loss would increase to $112 million (App. A, Tables 3b, 9b). In the short-run, prices would increase about 14 percent, consumers would lose $79 million per year and net revenues would decline $33 million per year. In the longer run, prices would increase about 12 percent, consumers would lose $68 million per year and net revenues would decline $43 million per year (App. A, 3b, 11b).

Tobacco (all varieties). An estimated 3.7 million pounds of methyl bromide is used to treat 95-100 percent of the total 6,416 acres of tobacco plant beds in Georgia, North Carolina, and South Carolina, and 50 percent of the 4,000 acres in Kentucky (App. A, Tables 2,4,5). These four States and Florida, a minor producing State, account for about 79 percent of the U.S. commercial tobacco production.

Kentucky data on production loss and acres treated were included in the five-State study area because Kentucky is a major tobacco-producing State. Growers using the alternatives of dazomet, metam-sodium, and Vorlex would increase control cost by about $5.2 million and lower production by an estimated 34,264 tons of tobacco (App. A, Table 3a,9a). The production losses reflect 10 percent of the production in Georgia and North Carolina (App. A, Table 10a).

In response to lower production, the price of tobacco is projected to increase by 9 percent, with an associated increase in growers' net revenue of $103 million and increase consumers' cost by $228 million. The total effect on the changes in growers' revenues plus consumers' cost is an estimated loss of $126 million. In the longer run when imports increase, price increases would moderate to less than 1 percent, consumers would lose $23 million per year, net revenues would decline $98 million per year, and the total economic loss would be $121 million per year.

Without Vorlex as an alternative, annual tobacco production would decrease by 34,552 tons (App. A, Table 9b). The short-run price increase would be 9 percent, consumers would lose $230 million per year, net revenues would increase $103 million per year, and the total economic loss would be $127 million per year (App. A, Tables 3b, 11b). In the longer-run, tobacco price would increase 1 percent, consumers would lose $23 million per year, net revenues would decline $99 million per year, and the total economic loss would be $121 million per year.

Tomatoes (fresh market). An estimated 13.1 million pounds of methyl bromide is used to treat 61 percent of the fresh market tomato acreage in the five-State study area, which accounts for about 86 percent of the U.S. commercial production (App. A, Tables 1,2,6). Using methyl bromide alternatives (Vorlex and metam-sodium) would increase control costs by an estimated $15.3 million and lower production by 214,972 tons, ranging from 81 percent of North Carolina's production to 1 percent of California's production (App. A, Tables 9a, 10a).

In response to lower production, the price of tomatoes is projected to increase by 22 percent, with an associated increase in growers' net revenue of $61 million and an increase of consumers' cost by $225 million. The total effect on the changes in growers' revenues plus consumers' cost is an estimated loss of $164 million of the benefits attributed to methyl bromide availability. In the longer-run when imports increase, price increases would moderate to 7 percent, consumers would lose $71 million per year, net revenues would decline $86 million per year, and the total economic loss would be $157 million per year.

If Vorlex is not available as an alternative to methyl bromide, annual production losses for fresh market tomatoes would more than double to 457,768 tons (App. A, Table 9b). Florida production would contribute 88 percent of the additional production loss. In this situation, Florida production is estimated to decline 46 percent. Economic impacts would increase dramatically. In the short-run, prices would increase 48 percent, consumers would lose $443 million per year, and net revenues would increase $82 million per year (App. A, Tables 3b, 11b). The total annual economic loss would be $361 million, more than 2.2 times the loss if Vorlex were available as an alternative. In the longer-run when imports increase, prices would increase 14 percent, consumers would lose $147 million per year, net revenues would decline $181 million per year. The total annual economic loss would be $327 million, about 2.1 times the loss if Vorlex were available as an alternative.

Minor Methyl Bromide-Crop Uses

Biologists indicate that the availability of feasible control alternatives to methyl bromide is very limited or nonexistent in some States for citrus (for postharvest transportation), cucumbers, eggplants, forest seedlings, grapes, and melons. In terms of the proportion of the 21-crop total, these crops account for minor amounts of methyl bromide use--citrus (<1 percent), cucumbers (<1 percent), eggplants (1 percent), forest seedlings (<1 percent), grapes (5 percent), and melons (5 percent).

Citrus (fresh market). An important use of methyl bromide in citrus is in postharvest fumigation by the Florida Department of Agriculture, which uses trucks to maintain control of the Caribbean fruit fly. There are no alternatives to methyl bromide for this purpose, which accounts for an estimated 102,000 pounds of methyl bromide used in fumigating about 4,080 citrus-loaded trucks annually (App. A, Table 2). According to biologists, the loss of methyl bromide availability for fumigating trucks would result in less revenue to Florida growers as citrus is diverted to processing and culling. Assuming an estimated 76,000-ton loss to fresh market citrus, and a projected 1 percent increase in price, the total economic effect is an estimated $25 million of loss in benefits attributed to methyl bromide availability.

Cucumbers (fresh and processing markets). In Florida, an estimated 1,700 acres of cucumbers are double-cropped on methyl bromide-treated land, where tomatoes or peppers were harvested. According to biologists, other potential chemical alternatives, metam-sodium and Vorlex, would not be sufficiently effective to allow a marketable crop to be produced. There are no acceptable nonchemical alternatives to methyl bromide. Thus, in Florida, the estimated 189,150 tons of lost production is valued at $72 million using constant prices. It is assumed that no other crops would be double-cropped with tomatoes or peppers in the first year of the ban.

Eggplants. About 2,050 acres of eggplants are grown in Florida, where an estimated 410,000 pounds of methyl bromide are used to treat 100 percent of the acreage. Methyl bromide is used at a rate of 200 pounds per acre with a treatment cost of $199 per acre. Biologists indicated there are no feasible chemical or nonchemical alternatives to methyl bromide. Nonchemical alternatives to control weeds include flaming, at $350 per acre, and hand hoeing, at $120 per acre. In Florida, without methyl bromide, other crops would be grown on land currently planted to eggplants. Using constant prices, the estimated 26,200 tons of loss in production using the methyl bromide alternatives is valued at about $12 million.

Forest Seedlings. The forest seedlings crop site category includes a wide variety of tree seedling types and varieties. As a result, time and data limitations required use of estimated constant (instead of projected) dollar valuations of production loss (s biological analysis). An estimated 320,074 pounds of methyl bromide are used to treat an average of 17 percent of the 1,446 acres of forest seedling acres in the five study States (App. A, Table 4, 6). Alternatives to methyl bromide include chloropicrin, dazomet, metam-sodium, Vorlex, glyphosate, and hand-weeding. Change in control cost would range from an estimated decrease of $396 per acre in California to an increase of $58 per acre in Florida. Using constant prices, the short-term or first-year production loss is valued at an estimated $34.8 million. It should be emphasized that the long-term economic implications without methyl bromide could be considerably more important than the first year estimate, assuming new alternatives to maintain yield and quality do not become available, and lower quality seedlings are produced and planted.

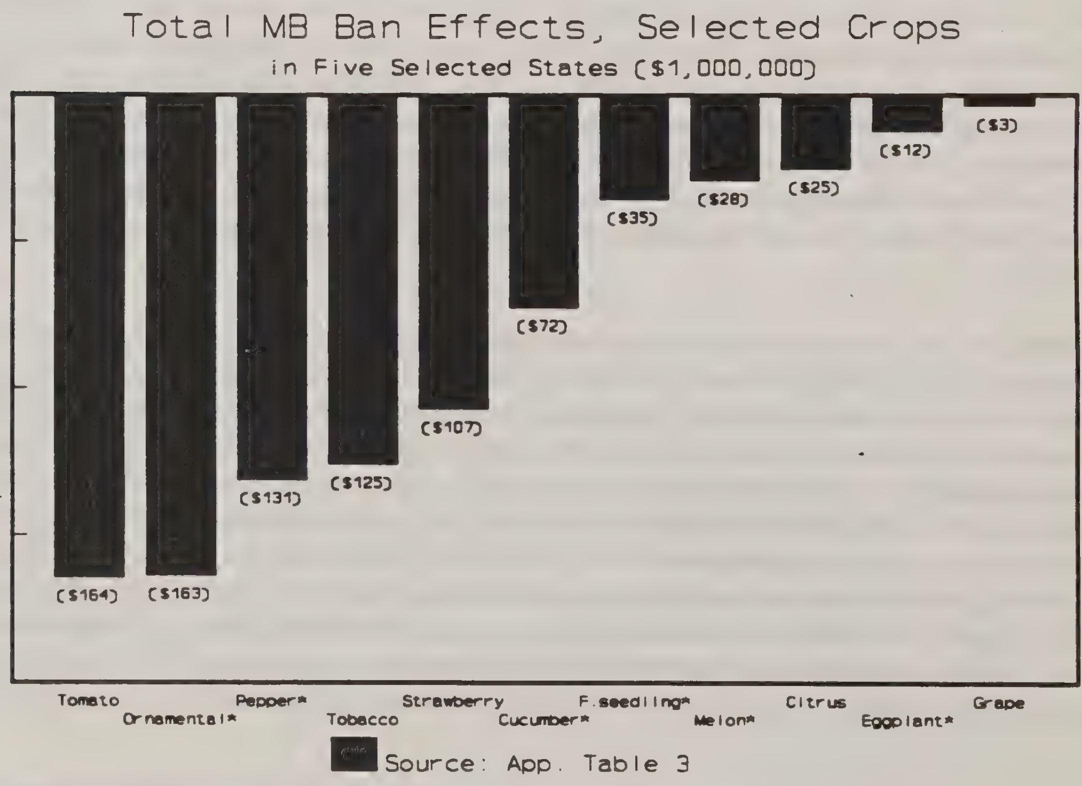
Grapes. An estimated 1.9 million pounds of methyl bromide are used to treat 4,838 or 0.6 percent of the California acres in the five-State study area (App. A, Table 2,6). The five-States account for about 93 percent of the U.S. commercial production (App. A, Table 1). Using metam-sodium and nonfumigant nematicide alternatives would lower control cost by about $1.2 million and result in lower production by an estimated 13,061 tons (App. A, Tables 9a, 10a).

In response to lower production, the price of grapes is projected to increase by less than 1 percent, with an associated increase in growers' net revenue of about $3 million and increase in consumers' cost by $6 million. The total effect is an estimated loss of $3 million of the benefits attributed to methyl bromide availability.

Melons (watermelon, honeydews, and miscellaneous melons). In the five States, an estimated 2.0 million pounds of methyl bromide are used to treat about 14,330 acres of honeydew melons and watermelons. Treated acreage ranges from 10,600 acres (20 percent of the total) in Florida to 380 acres (10 percent of the total) in North Carolina (App. A, Tables 5, 6). For the five States, the change in treatment cost per acre using methyl bromide alternatives ranges from a decrease of $200 in South Carolina to a $91 increase in Georgia and North Carolina. Metam-sodium and Vorlex were indicated as potential alternative treatments in California, Georgia, and North Carolina. Production losses would range from 23 percent of the crop in Florida to 3 percent or less in the other four study-area States Using constant prices, the estimated 92,750 tons of estimated reduced production is valued at $29.7 million. The voluntary cancellation of Vorlex would have little impact on melon production, and control costs would increase about $100,000 per year (App. A, Table 8b).

It should be emphasized that the experts' estimates of the proportion of acres planted, production losses, as well as the associated economic effects are for the 1991/92 crop years. The estimates could change with atypical weather, pest population outbreaks, or new nonchemical and chemical pest control strategies, etc. In the next section, cumulative economic effects and ratios of economic effects and methyl bromide use (quantity used, acres treated) are examined as potential guidelines for phasing out uses of methyl bromide.

Figure 5



*Evaluated using constant market price.

Of the 11 crops with estimated total economic effects of $3 million or over per crop, the effects with Vorlex available range from an estimated $164 million for tomatoes to $3 million for grapes (Figure 5). A phase-out could focus on major reductions in quantity of methyl bromide use without the adverse economic effects that generally follow an immediate cancellation of all uses. For example, a phase-out plan could include reducing the quantity of methyl bromide use (e.g. 70-90 percent) in the first 3-4 years while maintaining the most important economic benefits of methyl bromide use (e.g. 70-90 percent) for one or two decades longer, or until feasible alternatives are available. The process is illustrated in Table 9, where a phase-out of methyl bromide use in tomato production would reduce the use of methyl bromide by 35 percent of the 37.9-million-pound total while reducing by 19 percent the $856 million benefits attributed to methyl bromide availability. Adding a restriction on grapes would decrease methyl bromide use by an additional 5 percent, or a total of 40 percent, and decrease the benefits of methyl bromide by less than 1 percent. The banning of registered methyl bromide uses in production of tomatoes, grapes, strawberries, and melons would reduce the quantity of methyl bromide use by an estimated 60 percent and associated economic benefits of methyl bromide by 35 percent. The priority of selection could change if new fumigant alternatives become available, or if the impacts of crop use on human health is considered, e.g., tomatoes versus tobacco.

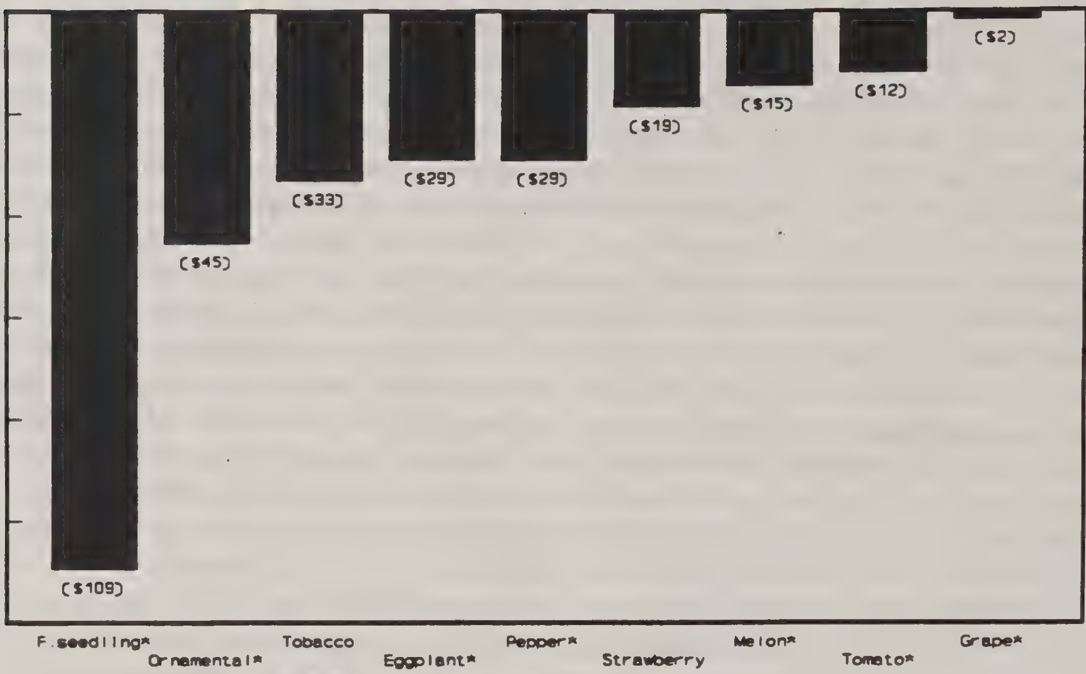
Table 9. Proportions of total methyl bromide quantity used and total economic effect, by selected crop

	Proportion of total MB use (37.9 mil.lb.)		Proportion of total economic effect ($856 million)	
	By crop	Cumulative	By crop	Cumulative
Tomatoes	35%	35%	19%	19%
Grapes	5%	40%	0.4%	19%
Strawberries	15%	55%	12%	32%
Melons	5%	60%	3%	35%
Peppers	12%	72%	15%	50%
Tobacco	10%	82%	14%	64%
Ornamentals	10%	92%	19%	83%
Other crops	8%	100%	17%	100%
Total	100%		100%	

The phase-out crop selection could consider total economic effects as a ratio of amounts used and acres treated. For example, a ratio of the total economic effect of a methyl bromide ban per pound used in providing control for a crop would have an estimated range of $109/lb. for forest seedlings to less than $20/lb. for strawberries, melons, tomatoes, and grapes (Figure 6). (Postharvest citrus, double-cropped cucumbers, and crops with minor impacts are not included.) Thus, based on each pound of active ingredient removed from use, the loss of methyl bromide availability and associated benefits would be more costly to society for forest seedlings than for the other four crops. Similar results are obtained using a ratio of the total economic effect per methyl bromide-treated acre, which indicates a $40,472/acre loss in benefits for forest seedlings compared with less than $3,000/acre loss for tomatoes, grapes, melons, and tobacco (Figure 7).

Figure 6

Ratio of Total Economic Effect per Lb. of MB Use by Crop
in Five Selected States (dollars/lb.)

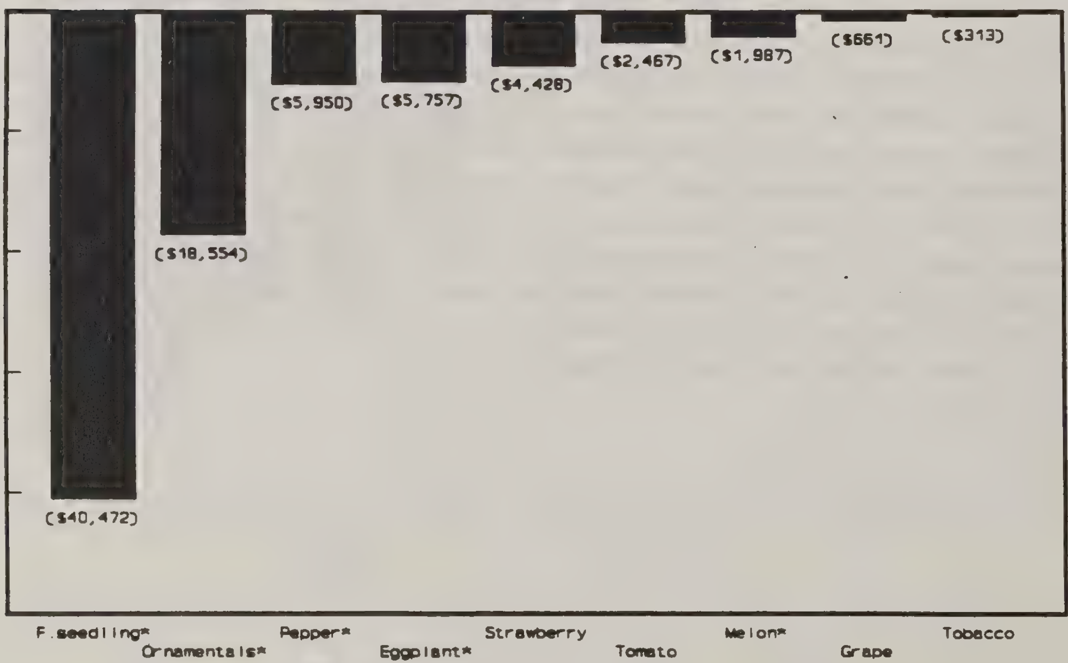


Source: App. Tables 2,3

*Evaluated using constant market price.

Figure 7

Ratio of Total Economic Effect per MB-Treated Acre
in Five Selected States (dollars/treated acre)



Source: App. Tables 2,3.

*Evaluated using constant market price.

Economic Model

A model is used to estimate the change in net revenue to growers, the increased cost to consumers, and the overall total effect of a methyl bromide ban that results in changes in control cost and yield. The change in growers production and projected price effects are used to determine the changes in grower and consumer surplus. A similar model was used in a 1988 assessment of methyl bromide and other fumigants (2).

The short-term economic specifications of a methyl bromide ban are expressed in equation 1 for a particular crop i + scenario j, where the superscripts b and a refer to periods before and after the ban with associated loss in yield. Farm-level price elasticities of demand are used to derive the new equilibrium price to reflect the change in production:

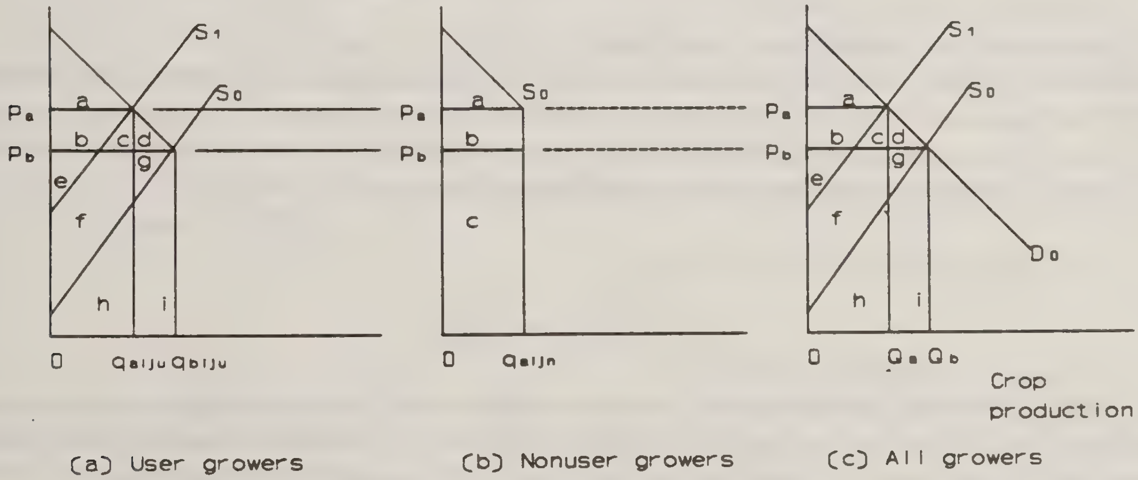
(1) $$P^a_{ij} = P^b_i(1/E^d_i X_{ij} + 1),\ X_{ij} = (Q^b_{ij} - Q^a_{ij})/Q^b_{ij}$$

where:

P^a_{ij} = price after change in production for crop i, scenario j;
P^b_i = base price for crop i, scenario j;
E^d_i = price elasticity of demand for crop i; and
X_{ij} = percent change in production due to infestation for crop i, scenario j.

At the initial equilibrium position, with methyl bromide available, total revenue from the sale of the crop equals P^bQ^b, or area e+f+g+h+i [See Figure 8(c)]. The initial surplus accruing to growers

Figure 8. Effects of a Pesticide Ban



equals area e+f+g. With higher cost and lower yield resulting from use of alternative control, the change in grower surplus, or area b-f-g, equals the change in total revenue, area b+c-g-i, minus the change in total cost, area c+f-i. This change in grower surplus could be positive or negative, depending on the price elasticities of demand and supply curves, and is measured as follows:

$$(2) \qquad I^{p}_{ij} = (P^{a}_{ij}Q^{a}_{ij}) - (P^{b}_{i}Q^{b}_{i}) - (A^{a}T_{ij}C^{a}_{ij})$$

where:

I^{p} = impact on growers of crop i
P = price per unit of crop (farm level), and
Q = total production of crop i, or acres planted x yield
A = acres planted of crop i
T = proportion of planted acres affected of crop i
C = change in control cost per acre for crop i

The short-term implications of higher prices would affect both previous users and nonusers of the banned pesticide. The impact on growers who previously used the pesticide can be determined by the change in surplus on acreage affected by the ban, illustrated by area -b+f+g in Figure 8(a), and measured by:

$$(3) \qquad I^{u}_{ij} = (P^{a}_{ij}q^{a}_{iju}T_{ij}) - (P^{b}_{i}q^{b}_{iju}T_{ij}) - (A_{i}^{a}T_{ij}C^{a}_{ij})$$

where:

I^{u} = impact on user-growers
T = proportion of planted acres affected, crop i, scenario j

Given perfect elasticity in the market for alternative controls, growers not having a pest problem or already using the alternatives to the banned pesticide would benefit from the higher crop prices without incurring cost increases (Figure 8(b)). The impact on nonuser growers can be derived by simply subtracting the impact on user growers, from the impact on all growers, or by using a procedure similar to those indicated in equations (3) and (4):

$$(4) \qquad I^{n}_{ij} = (P^{a}_{ij}q^{a}_{ijn}R) - (P^{b}_{i}q^{b}_{ijn}R),\ q^{a}iju = Q^{a}_{iju\,-\,qa}iju,\ Q^{b}_{iju\,-\,qb}iju$$

where:

I^{n} = impact on nonuser-growers
R = proportion of planted acres not affected

Consumers' willingness to purchase production Q^{b} is the entire area under the demand curve between zero and Q^{b}, or area a+b+...+h+i in Figure 8(c). At equilibrium market price, P^{b}, consumers pay only area e+f+g+h+i. Thus, the net benefit of having the pesticide available is area a+b+c+d. The pesticide use ban results in the loss of consumer surplus area (b+c+d), measured as follows:

$$(5) \qquad I^{c}_{ij} = (P^{b}_{ij}Q^{a}_{ij})-(P^{a}_{i}Q^{a}_{i})+0.5(P^{a}_{ij}-P^{b}_{i})(Q^{a}_{ij}-Q^{b}_{i})$$

where:

I^{c} = impact on consumers of crop i

The total change in welfare, or the impact on society, is defined as the change in grower surplus plus the change in consumer surplus, or area -(c+d+f+g) in Figure 8(c). This area reflects the change in real income redistribution -(c+f+g) plus the net loss in efficiency, area d, measured by simply adding change in grower surplus to the change in consumer surplus, or:

$$(6) \qquad I^{d}_{ij} = I^{p}_{ij} + I^{c}_{ij}$$

where:

I^{d} = total impact on grower net returns and consumer cost

The effect of a pesticide ban is to transfer income from consumers to growers through a higher price due to lower yield in the short term, and passed-on higher production cost in the long term as marginal growers shift out of production. In sum, a pesticide ban will likely cause a net loss in economic efficiency and a redistribution of income from consumers to growers, with windfall gains to nonuser growers, and gains or losses in benefits to user growers, depending on the crop's price elasticities of

demand, and the supply and cost of alternative control. The longer term effect of several years without new improved alternative control is loss of domestic and foreign markets, as growers shift into production of substitute crops.

Model Assumptions and Limitations

The cost-benefit methodology used in deriving the short-term economic impacts that occur during the first year of a methyl bromide ban entail a number of major assumptions and limitations:

1. As noted earlier, the estimates reflect short-term effects only. Among the longer term mechanisms not included are biological constraints, such as longer term reduction in the vigor and yield of perennial crops, eg., the fruit and nut tree crops; increases or decreases in planted acreage; or commodity imports which might substitute for and compete with the domestic crops studied.
2. The economic analysis does not include changes in the value of land, equipment, and other capital assets which might result from a methyl bromide ban.
3. Base year acres treated, costs, yields, and price elasticities of demand reflect the average yield of all growers of a specified crop in a typical or average production and consumption year.
4. Yield estimates with use of alternatives take into account the various responses of different cultivars and represent the total crop.
5. The utility of each dollar gained or lost is constant across various economic classes of growers and consumers.
6. The impacts do not quantify any economic implications of changes involving indemnification to farmers and manufacturers for pesticide inventories or changes in enforcement cost. Further, the short-term impacts do not take into account cost implications of changes in demand for alternative pesticides. For example, the supply functions for grower purchased inputs (labor, equipment, alternative pesticides) in each scenario are perfectly elastic.

Sources of Databases and Price Elasticities of Demand

The primary database for yield losses using methyl bromide chemical alternatives, rates, comparative cost, quantities of methyl bromide active ingredients used, and other biological related information was obtained from the USDA Methyl Bromide-Assessment Team. Base estimates of U.S. level production, acres planted, and prices were obtained from various USDA published estimates (1,7,8,9,10,11,12,13,14,15,16). Price elasticities of demand estimates were developed from published and unpublished sources (3,5,6).

Summary for Section II

This report provides estimates of the first year's economic effects on producers and consumers if methyl bromide use is lost because of cancellation or suspension by the Environmental Protection Agency or by manufacturer withdrawal. The States covered by the analysis include California, Florida, Georgia, North Carolina, and South Carolina. The total effects or benefits of methyl bromide availabilit' will result in a loss of an estimated $856-867 million in the five States for 21 crops. Without \orlex as an alternative, the losses would increase to $1.04-1.08 billion. For 15 of the 21 crops, the projected higher short-term prices for lower production levels, using the methyl bromide alternatives, would result in an estimated $133 million total gain in net revenue to growers ($153 million without Vorlex), which includes a $19 million increase in control costs ($10 million without Vorlex). For consumers, the short-term price effects of reduced production would increase consumption cost by $559 million ($782 million without Vorlex), which includes major cost increases for fresh market tomatoes ($225-443 million), tobacco products ($228 million) and strawberries ($76-79 million). Imports would moderate price ir -eases, resulting in producer losses of $225 million ($332 million without Vorlex) and consumer ıosses of $189 million ($269 million without Vorlex).

Constant market prices and change in control costs are used to evaluate the total effects or benefits of methyl bromide on the other six crops: cucumbers ($72 million), eggplants ($12 million), melons ($29 million), peppers ($131-135 million), ornamentals ($163-170 million), and forest seedlings ($35 million).

U.S. QUARANTINE USES OF METHYL BROMIDE

Agricultural quarantine seeks to balance the pest and disease risks associated with international trade against the benefits of that trade. Treatments such as methyl bromide fumigation, cold air, vapor heat, and hot water dip allow trade to take place for some commodities by reducing or removing the pest risks associated with these commodities. Methyl bromide is particularly important in quarantine efforts because it is effective against a variety of pests, including 'hitchhikers', and can be easily and economically applied to both small and large shipments.

U.S. regulations require that a wide array of imported food and nonfood commodities be fumigated with methyl bromide as a condition of entry. In addition, a number of commodities exported by the United States must be fumigated with methyl bromide in order to comply with the quarantine requirements of recipient countries. Economic information regarding U.S. imports and exports fumigated with methyl bromide is provided below.

IMPORTS

Food Imports

Sixteen fruits, thirteen vegetables, and seven nuts, seeds, and miscellaneous food products from more than 130 countries require methyl bromide fumigation or an alternative treatment as a condition of entry into the United States (table 10).[1] Methyl bromide fumigation of these products reduces or removes the risk of a number of pests associated with these products including *Brachycerus spp.*, *Diaprepes spp.*, *Eulia spp.*, *Naupactus spp.*, Bruchidae, and khapra beetle. Without methyl bromide fumigation, alternative treatments for all of these commodities from these sources would need to be found or shipments would have to be banned. Most alternative treatments currently available have narrow applicability or require further study before they can be approved for quarantine use. The loss of methyl bromide as a quarantine fumigant, therefore, would force a ban on imports of many of these commodities from these sources.

In 1989/1990, the United States imported an annual average of approximately 6.1 million metric tons of fresh fruits and vegetables. Of these fruits and vegetables, 0.4 million metric tons or 7 percent were fumigated with methyl bromide (table 11).[2] For 14 of the commodities included in table 11, the proportion of total imports fumigated with methyl bromide is shown in figure 9. Over 90 percent of U.S. imports of apricots, grapes, nectarines, peaches, plums, tangerines, and yams were fumigated with methyl bromide in 1989/1990.

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[1] A detailed listing of import requirements by commodity and country is given in Appendix B, numbers 1 - 3.

[2] Import data by origin was not available for cipollino, ethrog, horseradish, roselle, thyme, and tuna (fruit); imports of these items are not included in this total.

Table 10: Food Imports Requiring Methyl Bromide Fumigation or an Alternative Treatment as a Condition of Entry into the United States from Selected Countries

Fresh Fruits and Vegetables	*Other Foods*
Apples	Chestnuts, unprocessed or shelled
Apricots	Cucurbit Seeds, unprocessed, dried, roasted or salted
Asparagus	Cumin, unprocessed, roasted, or ground
Avocado	Dasheen, unprocessed, sliced, or pellets
Beans	Faba Bean, unprocessed
Brassica Oleraceae	Lentils, unprocessed
Cherries	Peppers, dried
Cipollino	
Ethrog	
Garlic	
Grapefruit	
Grapes	
Horseradish	
Kiwi	
Lemons	
Nectarines	
Okra	
Oranges	
Peaches	
Pears	
Peas	
Pigeon Peas	
Plum	
Quince	
Roselle	
Tangerine	
Thyme	
Tuna (fruit)	
Yam	

The significance of methyl bromide fumigated fruit and vegetable imports in the United States can be examined by evaluating the proportion of annual U.S. supplies represented by these imports (figure 10). In 1989/1990, fumigated grape imports represented over 30 percent of annual U.S. fresh grape supplies while methyl bromide fumigated peaches/nectarines, plums, and tangerines represented 7, 13, and 10 percent of annual U.S. supplies, respectively.

Many of the imported fruit items fumigated with methyl bromide fill an important niche in U.S. supplies. Imports of apricots, grapes, nectarines, peaches, and plums from Chile, in particular, enter the United States in winter months when U.S production is zero or near-zero. When U.S. supplies are examined over the months in which methyl bromide fumigated imports of these fruits arrive in the United States, a clearer picture of their importance emerges (figure 11). In 1989/1990, during the months when fumigated imports of apricots, grapes, and plums arrived in the United States, these imports represented over 50 percent of total U.S. supplies. Imported peaches and nectarines fumigated with methyl bromide represented an estimated 45 percent of U.S. supplies during the months they were imported, while imported tangerines represented 10 percent of U.S. supplies in 1989/1990.

An economic analysis was performed to measure the economic impact in the United States of a ban on methyl bromide fumigated imports of selected fruits. The fruits examined were: apricots, grapefruit,

grapes, lemons, oranges, peaches/nectarines, plums, and tangerines. A description of the model used for this analysis is described in appendix B, number 4.

For these nine commodities, estimated net losses resulting in the United States[3] over five years from a ban on imports of these items range from $1,681.6 to $1,707.4 million (table 12). In general, the reduction in supply caused by bans placed on imports of these commodities results in increased prices which favor producers and harm consumers; in this case, consumer losses outweigh producer gains. Estimated total U.S. producer[4] gains range from $3,006.0 to $3,289.8 million over five years. Over 70 percent of U.S. producer gains are attributed to grapes, peaches, and nectarines. Another 10 percent of producer gains accrue from plums. Estimated total U.S. consumer losses range from $4,687.6 to $4,997.2 million. Approximately 75 percent of consumer losses are attributed to grapes, peaches, and nectarines. An additional 14 to 15 percent of all consumer losses can be attributed to plums.

Other imports

Unprocessed seeds and nuts for propagation, analytical, or industrial purposes; hays and straws; cotton products; gums; bagging; and brassware are among the nonfood items requiring methyl bromide fumigation. Imports of many of these items are fumigated in order to reduce or eliminate the presence of a number of pests including khapra beetles, pink bollworm, and seed bruchids. Import information is difficult to obtain for these specific commodities as trade statistics often include these items within broad categories. In addition, many of these commodities require methyl bromide fumigation under very limited circumstances.

For those nonfood commodities for which import data was available, the estimated value of total imports requiring methyl bromide fumigation or an alternative treatment ranges from $1,000 for rice straw and fiber to $306 million for cut flowers (table 13). In general, a very high proportion of total U.S. imports of these commodities require methyl bromide fumigation or an alternative treatment.

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[3] Losses would also occur in exporting countries subject to the ban. For these nine fruits, Chile and Mexico would be most affected. Chilean exports of apricots, peaches/nectarines, plums, and grapes account for approximately 10, 32, 40, and 70 percent of Chilean production, respectively. More than half of these exports are marketed in the United States. Mexican exports of citrus to the United States represent a much smaller proportion of total Mexican production.

[4] The analysis was conducted at the retail level, therefore, U.S. producers include both U.S. fruit growers and marketers (importers, wholesalers, and retailers).

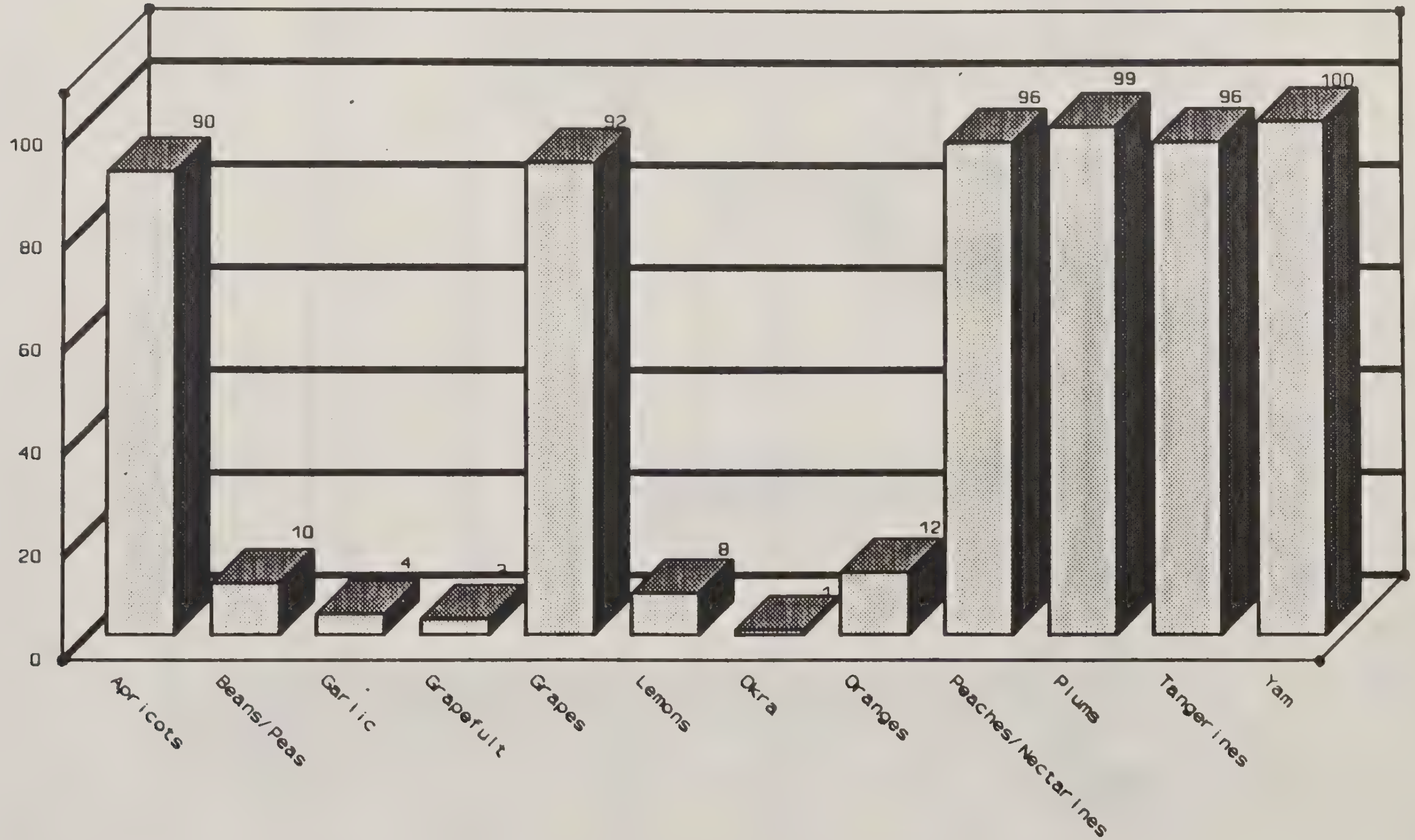
Table 11: Trade Data For Fruit And Vegetable Imports Treated By Methyl Bromide Fumigation

Commodity	Total Annual U.S. Imports (1989/1990 Average)		U.S. Imports Fumigated with Methyl Bromide (1989/1990 Average)	
	(Metric Tons)	($1000)	(Metric Tons)	($1000)
Apricots	901	892	806	702
Beans/Peas	33,434	37,313	3,343	373
Brassica Oleracea	65,278	17,783	23	27
Garlic	17,309	15,747	645	1,345
Grapefruit	4,945	879	159	28
Grapes	327,135	250,493	302,502	22,422
Kiwi	26,587	33,213	34	75
Lemons	8,556	1,281	651	250
Okra	18,484	4,919	185	49
Oranges	9,418	4,142	1,102	289
Peaches/Nectarines	47,968	31,578	46,024	29,999
Plums	22,052	14,036	21,740	13,844
Tangerines	12,617	4,191	12,134	3,859
Yam	18,169	10,769	18,169	10,769

Note: 1989/1990 Trade Data for Cipollino, Ethrog, Horseradish, Roselle, Thyme, and Tuna (fruit) was unavailable by country of origin.

Sources: U.S. Department of Commerce, U.S. Imports for Consumption.
U.S. Department of Agriculture, ERS, U.S. Imports of Fruits and Vegetables under Plant Quarantine Regulations.

Figure 9: Percentage of Total U.S. Imports Fumigated with Methyl Bromide, 1989/1990



Note: Fumigated Imports of Brassica Oleracea and Kiwi Were Less than 1% of Total Imports in 1989/1990

Figure 10: Imports Treated with Methyl Bromide as a Percentage of Annual U.S. Supplies, 1989/1990

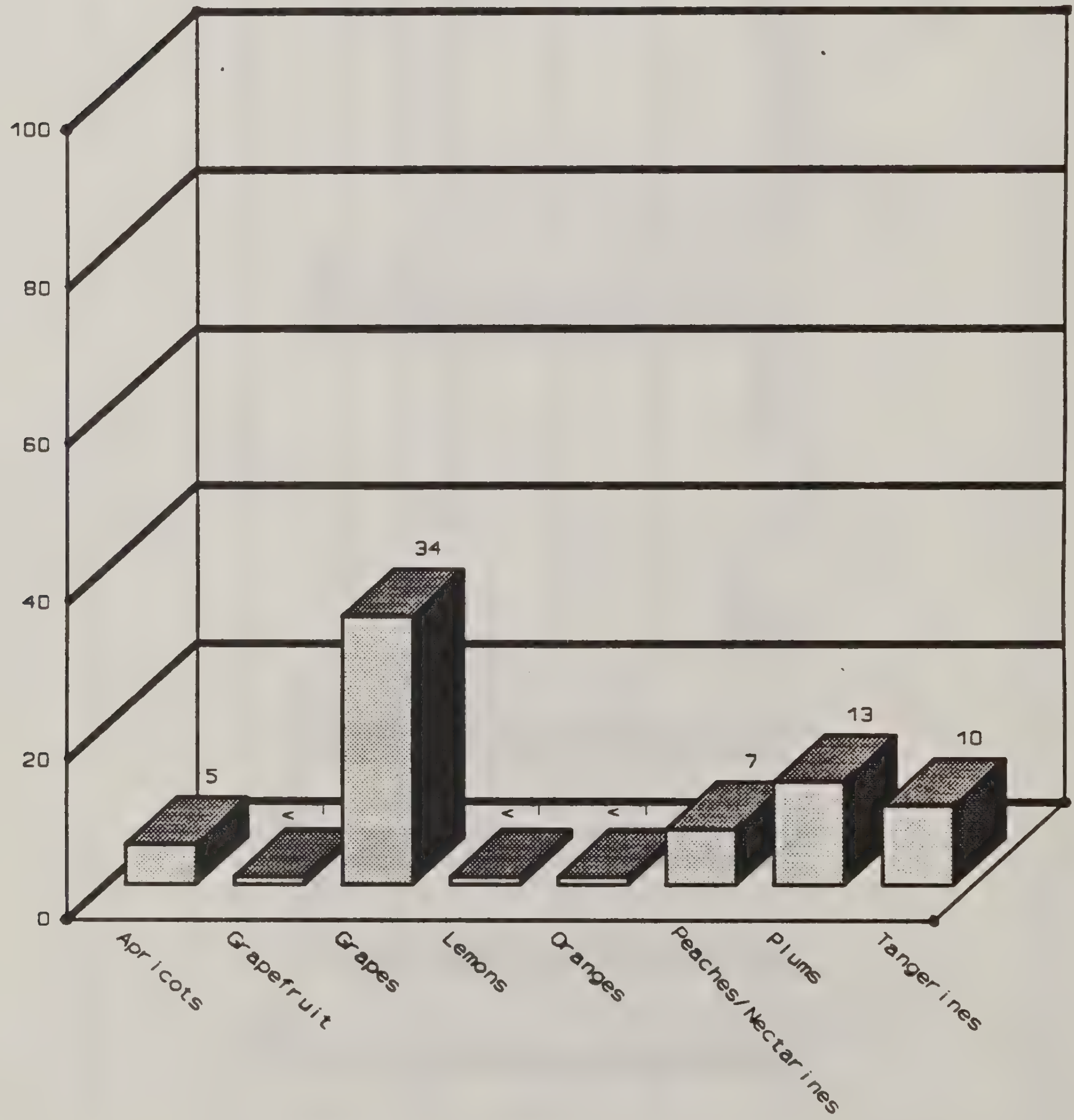
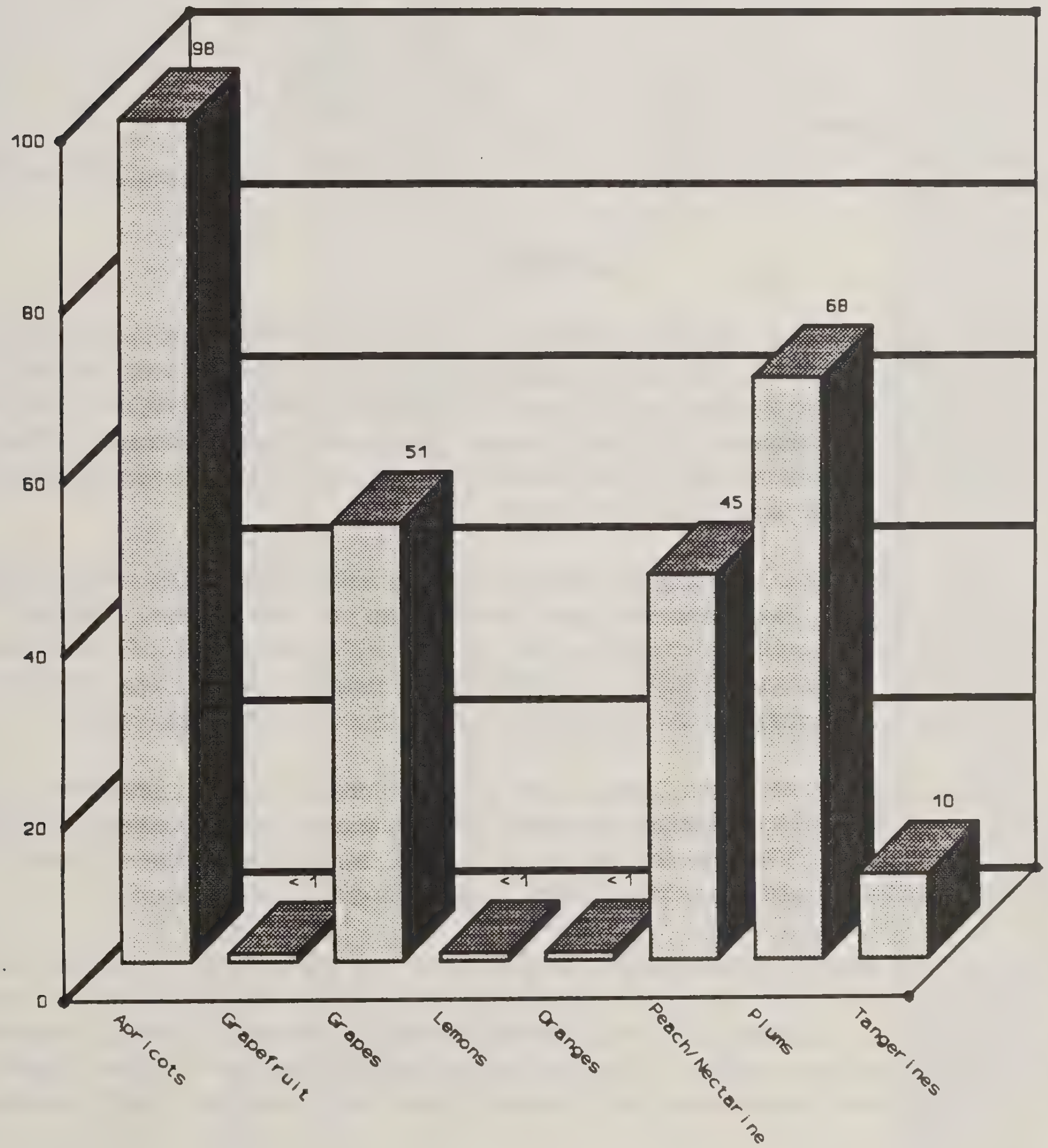


Figure 11: Imports Treated with Methyl Bromide as a Percentage of U.S. Supplies During Selected Months, 1989/1990



Apricots -- January, December
Grapefruit -- January, August-September
Grapes -- January-June, October-December
Lemons -- June-October
Oranges -- January -June, September-December
Peaches/Nectarines -- January-May, November-December
Plums -- January-May, December
Tangerines -- January-March, October-December

Table 12: Economic Impact of a Ban on Methyl Bromide Fumigated Imports of Nine Selected Commodities in the United States (Summed over Five Years)			
COMMODITY	U.S. PRODUCER GAINS	U.S. CONSUMER LOSSES	NET LOSSES IN THE U.S.
	(MILLION DOLLARS)	(MILLION DOLLARS)	(MILLION DOLLARS)
APRICOTS	0	30.4 - 31.4	30.4 - 31.4
GRAPEFRUIT	2.0 - 3.4	2.0 - 3.4	<0.1
GRAPES	1,115.5 - 1,141.3	1,821.1 - 1,849.3	705.6 - 707.9
LEMONS	17.4 - 29.2	18.1 - 30.6	0.8 - 1.3
ORANGES	3.0 - 5.1	3.0 - 5.1	<0.1
PEACHES/NECTARINES	1,259.2 - 1,318.9	1,832.0 - 1,894.4	572.8 - 575.5
PLUMS	326.7 - 334.3	689.5 - 697.5	362.8 - 363.2
TANGERINES	282.1 - 457.5	291.4 - 485.4	[illegible].3 - 27.9
TOTAL	3,006.0 - 3,289.8	4,687.6 - 4,997.2	[illegible],681.6 - 1,707.4

EXPORTS

U.S. exports of cherries, cotton, oak logs, peaches, nectarines, strawberries, and walnuts to particular countries must be fumigated with methyl bromide to fulfill quarantine requirements of those countries. Over the four-year period, 1988/1989 to 1991/1992, U.S. exports requiring methyl bromide fumigation averaged more than $200 million per year (table 14). In 1991/1992, 60 percent of U.S. cherry exports, 28 percent of oak log exports, and smaller percentages of cotton, peach, nectarine, strawberry, and walnut exports needed to be treated with methyl bromide before entry would be allowed by the importing country (figure 12).

Methyl bromide is utilized to reduce or eliminate the risks posed by a number of pests associated with these commodities, including Lepidoptera, Japanese beetles, pink bollworm, and oak wilt disease. The loss of methyl bromide as a quarantine fumigant would likely result in a ban by many of the recipient countries on these commodities shipped from the United States. Either alternative export markets would need to be found for the fumigated products, or they would remain in the United States and, in the short run, could depress U.S. prices.

For certain commodities exported by the United States, such as tobacco, methyl bromide fumigation is one of the alternative import treatments required by particular countries. Tobacco exports worth more than $30 million were treated with methyl bromide in 1991/1992. In addition, certain exports, such as strawberries shipped to Japan, are regularly fumigated with methyl bromide, even though there is no phytosanitary requirement.

When fumigated commodities for which treatment with methyl bromide is not mandatory or for which treatment alternatives currently exist are being considered, the potential impact of loss of methyl bromide as a quarantine treatment becomes all the greater. Exports of these commodities would be affected, if only by increased dependence upon alternative treatment methods. Trade volumes would likely decline for those exports for which methyl bromide fumigation is not a requirement, but is used to improve the marketability of the products.

Table 13: Economic Information for Selected Nonfood Imports, 1989/1990 Average

	U.S. Imports Requiring Methyl Bromide Fumigation or Alternative Treatment[1]		Total U.S. Imports	
Commodity	Metric Tons (1989-1990 Average)[2]	Value ($1000)	Value ($1000)	U.S. Imports Requiring Methyl Bromide or Alternative as % of Total U.S. Imports
Bags, Bagging, or Covers[3]	7,944	7,675	8,444	90.9%
Broomcorn	6,002	9,632	9,632	100.0%
Cottonseed	1,616	235	235	100.0%
Cotton Lint[4]	NA	6,473	6,473	100.0%
Cotton Linters	21,151	12,848	12,848	100.0%
Cotton Waste and Fibers of Cotton[3]	1,347	615	615	100.0%
Cut Flowers	NA	305,995	305,995	100.0%
Goatskins, Lambskins, Sheepskins[3]	NA	5,025	35,358	14.2%
Gums and Resins	4,458	5,958	12,139	49.1%
Rice Straw and Fiber[3]	NA	1	1	100.0%
Seeds for Propagation Vetch[3]	NA	6	6	100.0%

Sources: United Nations, Food and Agriculture Organization. Trade Yearbooks 1987 and 1988.
USDA, FAS, Foreign Agricultural Trade Statistics of the United States, 1987 and 1988.
USDA, NASS, Agricultural Statistics, 1988.
U.S. Department of Commerce, Bureau of the Census. U.S. General Imports World Area and Country of Origin by Schedule A Commodity Groupings, 1987.
US. Department of Commerce, Bureau of the Census: U.S. Imports for Consumption. Report FT247/1989 and 1990.

1 Economic information is difficult to obtain for the items listed in appendix B, number 3. Much of the data shown in these columns is for broader categories of items that actually require methyl bromide fumigation. In addition, many of the commodities shown in appendix B, number 3 require methyl bromide fumigation only under particular conditions. The values shown in this column thus generally overstate the potentially affected imports.
2 NA = Not Available
3 Data shown are 1989 values.
4 Data shown are 1985-1987 average values.

Table 14: Value of U.S. Exports Requiring Methyl Bromide Treatment

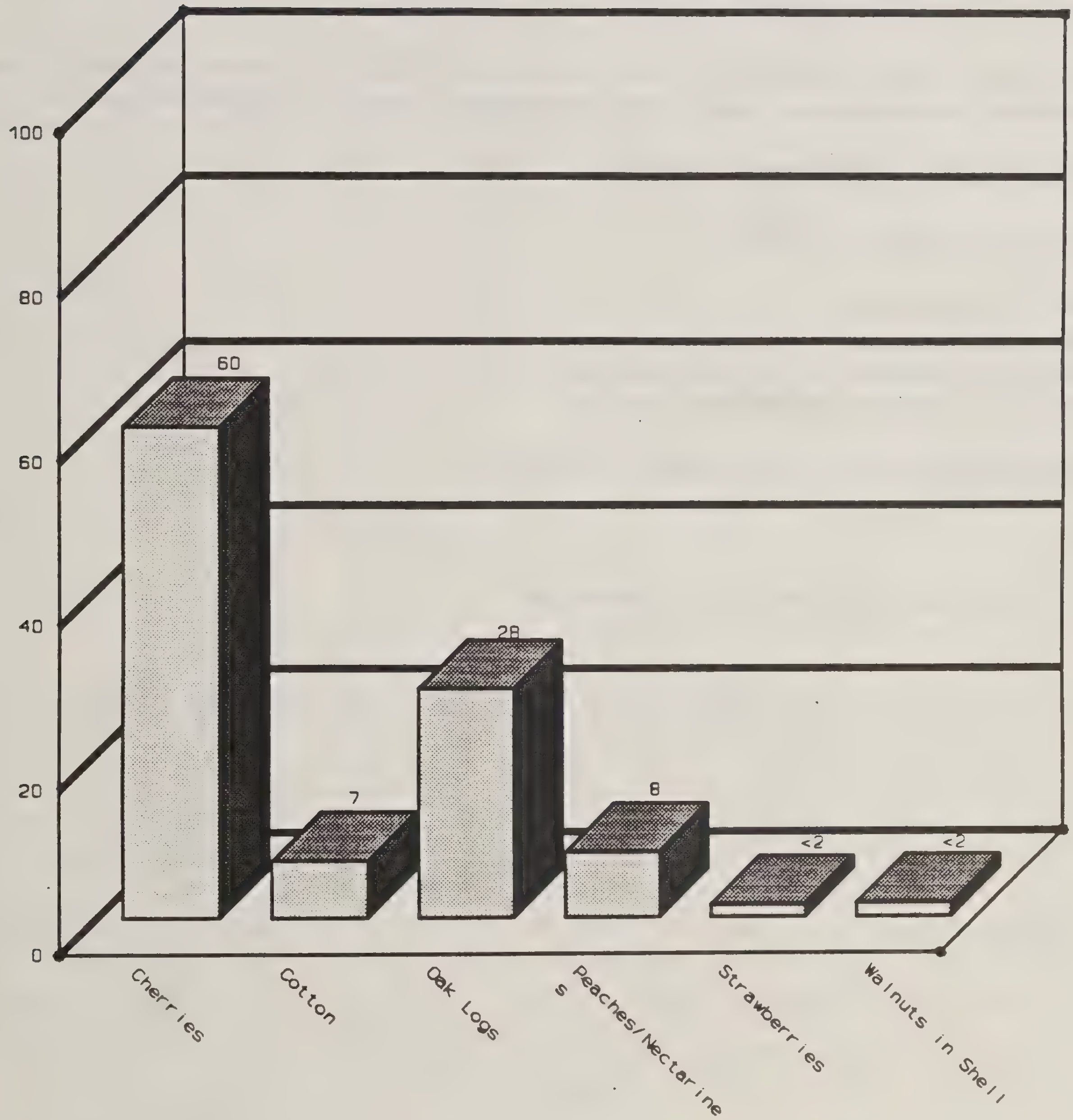
Commodity	Receiving Country(ies) Requiring Methyl Bromide Fumigation	Value in Current Dollars			
		10/88-9/89	10/89-9/90	10/90-9/91	10/91-9/92
Cherries	Japan	40,348,631	37,427,665	33,539,321	62,289,838
	Korea	438,880	541,179	254,004	400,365
Cotton	Egypt	58,075,307	96,645,575	88,092,061	124,583,434
	Bangladesh[1]	22,647,922	36,608,512	18,697,863	9,374,163
	Pakistan[1]	1,017,715	2,564,283	814,625	1,674,853
	El Salvador	4,176,585	808,490	6,410,249	4,801,400
	Guatemala	87,537	368,456	1,192,656	1,289,769
	Peru	0	0	18,624	1,209,557
Oak Logs[2]	EEC	42,499,429	33,089,406	29,000,722	26,093,441
	Mexico	1,725,767	2,054,316	1,537,604	3,186,199
	Austria[3]	902,003	259,002	64,964	49,065
Peaches/Nectarines	Japan[4]	577,266	265,925	26,682	0
	Mexico[5]	0	0	6,619,648	4,951,910
Strawberries[6]	Australia	2,306,224	931,584	1,685,327	1,335,784
Walnuts in Shell	Japan	2,121,013	1,791,851	1,004,640	1,683,555
Total		176,924,279	213,356,244	188,958,990	242,923,333

Sources: USDA, Animal and Plant Health Inspection Service and Foreign Agricultural Service.

1 Bangladesh and Pakistan require that their cotton imports be treated with methyl bromide, but the fumigation may be done at the port of entry.
2 Methyl bromide fumigation is an optional treatment for oak logs exported to Switzerland. Data on quantities fumigated is not available.
3 Oak logs to Austria require treatment only when shipped between May 1 and October 14.
4 Japan does not import peaches, only nectarines.
5 Before 1991, peaches and nectarines exported to Mexico did not require fumigation with methyl bromide.
6 Treatment with methyl bromide is an option for strawberry exports to New Zealand, but generally shipments are only sampled and examined. There is no phytosanitary requirement for methyl bromide treatment of strawberries exported to Japan, however shippers regularly do so to ensure entry.

Figure 12: Percentage of U.S. Exports Requiring Fumigation with Methyl Bromide, 1991/1992

(By Value)



METHODOLOGY

The economic impact in the United States of banning imports of selected fresh fruits from countries for which methyl bromide fumigation is required as a condition of entry was estimated. The fruits selected were: apricots, grapefruit, grapes, lemons, nectarines, oranges, peaches, plums, and tangerines

ECONOMIC MODEL

Gains and losses in the United States resulting from the loss of methyl bromide as a quarantine fumigant were estimated by evaluating changes in market (demand and supply) equilibriums. Changes in U.S. producer and U.S. consumer surpluses resulting from the new levels of supply and price caused by the ban were estimated for each of the nine selected commodities. The net impact in the United States was calculated as the sum of these changes.[5] A graphical representation of the model used is provided in figure 9.

The initial or base supply of each commodity (Q^o) was assumed to be fixed and the domestic and foreign components of this supply were treated as homogeneous products. The initial supply of each commodity was equal to[6]:

$$Q^o_i = USPRO_i - USEXP_i + USIMPNR_i + USIMPR_i \qquad (1)$$

where, for each commodity (i = 1, 2,... 9),

USPRO = U.S. production;
USEXP = U.S. exports;
USIMPNR = U.S. imports from nonrestricted countries;
USIMPR = U.S. imports from restricted countries.

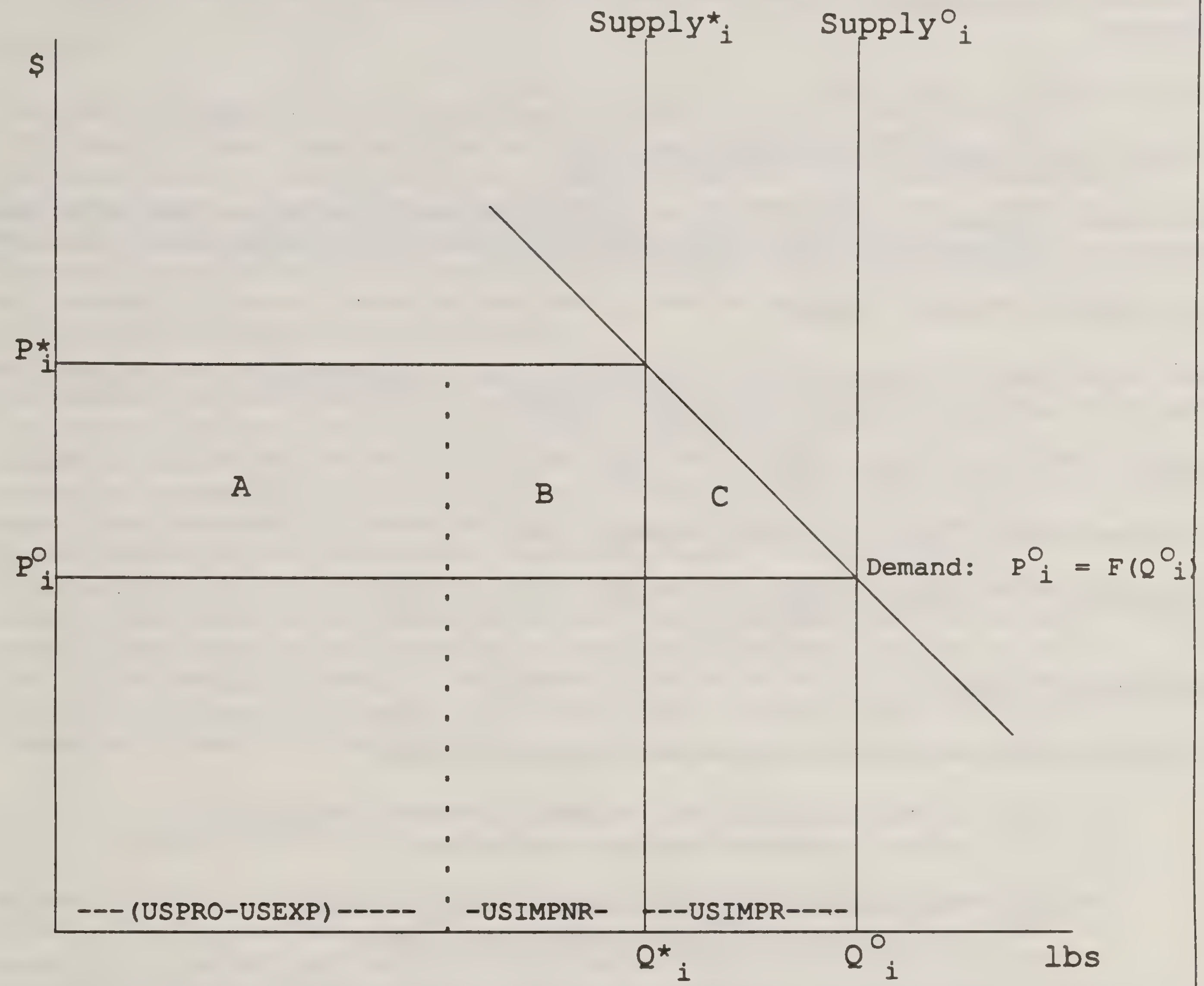
An inverse linear demand curve was assumed for each commodity:

$$P^o_i = f(Q^o_i) \qquad (2)$$

where P^o_i = initial or base retail price for each commodity

[5] Producers and consumers in the restricted and nonrestricted countries would also be affected by the cancellation of MB. Net impacts on these groups were not estimated, however.

[6] Production, exports, and imports were totaled only for those months when imports generally arrive from the restricted countries.



▲ U.S. Producer Surplus $= (P^*_i - P^O_i)\ (USPRO_i - USEXP_i)$
$= \text{Area A}$

▲ U.S. Consumer Surplus $= -[(P^*_i - P^O_i)Q^*_i + .5(P^*_i - P^O_i)(Q^O_i - Q^*_i)]$
$= - \text{Area A} - \text{Area B} - \text{Area C}$

Net impact in the U.S. $= [\ (P^*_i - P^O_i)\ (USPRO_i - USEXP_i)] - [(P^*_i - P^O_i)(Q^*_i + .5(Q^O_i - Q^*_i))]$
$= \text{Area A} - \text{Area A} - \text{Area B} - \text{Area C}$
$= - \text{Area B} - \text{Area C}$

Figure 1 Economic Model of MB Cancellation as a Quarantine Fumigant

New supplies in the United States after the ban were equal to[5]:

$$Q^*_i = USPRO_i - USEXP_i + USIMPNR_i \quad (3)$$

New U.S. retail prices resulting from the ban were calculated by treating markets for each of the nine fruits independently[5]:

$$P^*_i = (P^o_i/E_i)[((Q^*_i - Q^o_i)/Q^o_i) + E_i] \quad (4)$$

where E_i = price elasticity of demand for each commodity.

A ban on imports will cause U.S. producers[7] to receive a gain because prices increase and they suffer no decrease in the quantity which they are supplying. The gain to U.S. producers was calculated as a change in producer surplus (PS):

$$\Delta PS = (P^*_i - P^o_i)\,(USPRO_i - USEXP_i) \quad (5)$$

A ban on imports causes U.S. consumers to lose as the quantity available in the marketplace drops and prices increase. The loss to U.S. consumers was calculated as a change in consumer surplus (CS):

$$\Delta CS = -[(P^*_i - P^o_i)(Q^*_i + .5(Q^o_i - Q^*_i))] \quad (6)$$

The net impact in the U.S. each year is the sum of equations 5 and 6:

$$\text{Net impact} = [(P^*_i-P^o_i)(USPRO_i-USEXP_i)] - [(P^*_i-P^o_i)(Q^*_i + .5(Q^o_i - Q^*_i))] \quad (7)$$

HYPOTHETICAL CASES

The net impact in the United States was calculated over five years for two cases:

Case 1 - no behavioral changes would be made by producers or consumers over the five year period considered in the analysis;

Case 2 - limited behavioral adjustments would be made by producers in both the United States and the nonrestricted countries.

In terms of the economic model, case 1 implies that $Q^*_{i1} = Q^*_{i2} = Q^*_{i3} = Q^*_{i4} = Q^*_{i5}$ and $P^*_{i1} = P^*_{i2} = P^*_{i3} = P^*_{i4} = P^*_{i5}$. Under case 2, changes may occur in U.S. production, exports, and/or imports from nonrestricted countries which partially compensate for the banned imports, hence, $Q^*_{i1} < Q^*_{i2} < Q^*_{i3} < Q^*_{i4} < Q^*_{i5}$ and $P^*_{i1} > P^*_{i2} > P^*_{i3} > P^*_{i4} > P^*_{i5}$.

The net impact in the United States over five years is the sum of the discounted annual impacts.[8]

[7] SINCE THE ANALYSIS IS CONDUCTED AT THE RETAIL LEVEL, U.S. PRODUCERS INCLUDE BOTH U.S. FRUIT GROWERS AND MARKETERS (IMPORTERS, WHOLESALERS, RETAILERS) ALLOCATING GAINS AMONG THESE ENTITIES WAS BEYOND THE SCOPE OF THIS RESEARCH.

[8] A 10 PERCENT DISCOUNT RATE WAS APPLIED.

EMPIRICAL ESTIMATION

SUPPLY

Total annual U.S. supplies of each commodity were calculated using U.S. production, export, and import data. Production, export, and import data were obtained for 1989 and 1990 from National Agricultural Statistics Service (NASS), Economic Research Service (ERS), and Foreign Agricultural Service (FAS) sources. These 1989 and 1990 annual figures were averaged and monthly production and import figures were derived from these annual averages using information obtained from the Agricultural Marketing Service (AMS) regarding monthly shipments of fresh fruits. Base supplies for each commodity (Q^o_i) were calculated for those months in which imports arrive in the United States from the restricted countries according to equation 1.

New supplies of each commodity (Q^*_i) were calculated for cases 1 and 2 according to equation 3. Prospects for additional U.S. production, reduced exports, and/or additional imports from the nonrestricted countries were evaluated for each commodity. Large quantities of grapefruit, lemons, oranges, and tangerines are available from other sources during the months when the United States imports these commodities from Mexico and Chile. For case 2, 90 percent of the banned citrus imports were assumed to be replaced after 5 years by other sources. For apricots, grapes, nectarines/peaches, and plums, prospects for replacement of the banned imports by other sources were dimmer. Chile, the main or sole supplier of these fruits, exports to the United States during months when U.S. production is minimal. In addition, the quantity of Chilean exports cannot be matched by other Southern Hemisphere countries. It was projected in this analysis that only 5 percent of the banned grape and plum imports would be replaced after 5 years, 10 percent of the nectarine/peach imports, and 30 percent of the apricot imports.

PRICE AND ELASTICITY

Monthly retail prices for 1989 and 1990 were obtained from the Bureau of Labor Statistics (BLS) or estimated from BLS data. Prices for 1989 were converted into 1990 dollars and 1989 and 1990 monthly prices were averaged. Base prices (P^o_i) for each commodity were calculated by multiplying the monthly U.S. supply of each commodity by the monthly retail price for those months in which imports arrive in the United States from the restricted countries. These monthly dollar figures were then summed and divided by the total base supply to obtain a weighted retail price per pound for each commodity. Retail level demand elasticities were obtained for each commodity from ERS. Demand elasticities of -.2 for apricots, grapefruit, lemons, nectarines/peaches, plums, and tangarines; -1 for oranges; and -1.4 for grapes were used.[9]

New prices were calculated for each commodity according to equation 4.

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[9] Separate elasticities were not estimated for apricots, lemons, nectarines/peaches, plums, and tangerines. For these commodities, the elasticity reported for other fresh fruits was utilized.

APPENDICES

Table 1. Scope of Economic Analysis Study Area -- States, Crops, Production

Crop	U.S. 1989-91 average production	Selected states, proportion of U.S. production	1989-91 average production: Total	California	Florida	Georgia	North Carolina	South Carolina
	1,000 tons		-- 1,000 tons --					
Fruits\nuts:								
Almonds	270	100%	270	270	--	--	--	--
Apples	4,898	11%	526	376	--	13	118	19
Apricots	110	98%	108	108	--	--	--	--
Cherries	262	11%	28	28	--	--	--	--
Citrus	11,790	96%	11,365	2,898	8,467	--	--	--
Grapes	5,716	92%	5,275	5,270	--	3	2	0.5
Nectarines	219	100%	219	219	--	--	--	--
Peaches	1,210	82%	991	799	--	68	10	115
Plums/prunes	851	47%	403	403	--	--	--	--
Walnuts	235	100%	235	235	--	--	--	--
Vegetables:								
Carrots	1,434	94%	1,343	810	534	--	--	--
Cucumbers	\a	\a	384	57	189	--	95	42
Eggplant	\a	\a	26	--	26	--	--	--
Melons	\a	\a	962	403	362	55	33	109
Peppers	\a	\a	650	296	225	77	52	--
Strawberries	633	83%	528	454	63	--	7	4
Sweet potatoes	599	51%	306	36	--	36	218	16
Tomatoes, fresh	1,717	86%	1,473	481	874	37	13	69
Field crops:								
Tobacco \b \c								
Field transplanted	776	79%	610	--	9	45	303	54
Ornamentals	\a	\a	\c	\c	\c	\c	\c	\c
Forest seedlings	\a	\a	\c	\c	\c	\c	\c	\c

\a Data not available.
\b Selected states total includes 199,418 tons of tobacco produced in Kentucky.
\c See biological section for production (in millions of plants) of tobacco, ornamental, and forest plants.

Table 2. Methyl bromide Use on Selected Crops

Crop	State(s)	Acres treated	Rate	Methyl bromide use: Total	Proportion
			Lbs.	Lbs.	
Fruits\nuts:					
Almonds	CA	1,803	400	721,200	1.9%
Apples	CA	450	400	180,000	0.5%
Apricots	CA	75	400	30,000	0.1%
Cherries	CA	224	400	89,600	0.2%
Citrus	FL	\a	\a	102,000	0.3%
Grapes	CA	4,838	400	1,935,200	5.1%
Nectarines	CA	791	400	316,400	0.8%
Peaches	CA	1,586	400	634,400	1.7%
Plums/prunes	CA	740	400	296,000	0.8%
Walnuts	CA	481	400	192,400	0.5%
Subtotal		10,988	409	4,497,200	11.9%
Vegetables:					
Carrots		9	225	2,025	0.0%
Cucumbers	FL	\b	\b	0	0.0%
Eggplant	FL	2,050	200	410,000	1.1%
Melons	CA,FL,GA,NC,SC	14,329	137	1,962,600	5.2%
Peppers	CA,FL,GA,NC	21,968	205	4,512,400	11.9%
Strawberries	CA,FL,NC,SC	24,049	237	5,708,100	15.1%
Sweet potatoes	CA	45	200	9,000	0.0%
Tomatoes, fresh mkt.	CA,FL,GA,NC,SC	63,466	207	13,111,100	34.6%
Subtotal		125,916	204	25,715,225	67.8%
Miscellaneous crops:					
Tobacco					
Plant Bed \c	GA,NC,SC	8,275	445	3,682,375	9.7%
Ornamentals	CA,FL,NC	9,047	410	3,712,550	9.8%
Forest seedlings	CA,FL,GA,NC,SC	865	370	320,074	0.8%
Subtotal		18,187	424	7,714,999	20.3%
Total, selected crops		155,091	245	37,927,424	100.0%

\a Use of methyl bromide is on post harvest fumigation of trucked citrus in Florida.
\b Cucumbers double-cropped after harvest of tobacco or pepper on methyl bromide-treated acres.
\c Tobacco methyl bromide use includes treatment of 2,000 acres of plant beds in Kentucky.

Table 3a. With Vorlex: Projected Effects of methyl bromide Ban With and Without Imports, Growers and Consumers

Crop	Without imports: Change in growers': Control cost	Without imports: Change in growers': Revenue	Without imports: Change in growers': Net revenue	Without imports: Change in consumer cost	Without imports: Total impact	With imports: Change in growers': Revenue	With imports: Change in growers': Net revenue	With imports: Change in consumer cost	With imports: Total impact
	Million dollars								
Crops with losses valued using projected market prices:									
Fruits\nuts:									
Almonds	-0.856	0.3	1.2	0.5	0.7	0.3	1.2	0.5	0.7
Apples	-0.038	0.4	0.4	0.8	-0.4	0.4	0.4	0.8	-0.4
Apricots	-0.002	0.0	0.0	0.2	-0.2	0.0	0.0	0.2	-0.2
Cherries	-0.006	0.7	0.7	0.4	0.3	0.7	0.7	0.4	0.3
Citrus	-0.490	-6.4	-5.9	18.6	-24.5	-6.4	-5.9	18.6	-24.5
Grapes	-1.210	1.8	3.0	6.2	-3.2	1.8	3.0	6.2	-3.2
Nectarines	-0.109	0.1	0.2	1.1	-0.9	0.1	0.2	1.1	-0.9
Peaches	-0.218	0.1	0.3	1.1	-0.8	0.1	0.3	1.1	-0.8
Plums/prunes	-0.019	0.1	0.1	0.5	-0.4	0.1	0.1	0.5	-0.4
Walnuts	-0.012	0.7	0.7	1.6	-0.9	0.7	0.7	1.6	-0.9
Subtotal	-2.959	-2.2	0.7	31.0	-30.3	-2.2	0.7	31.0	-30.3
Vegetables:									
Carrots	0.003	0.0	0.0	-0.3	0.3	0.0	0.0	-0.3	0.3
Strawberries	1.092	-29.8	-30.9	75.7	-106.6	-40.2	-41.3	65.2	-106.5
Sweet potatoes	0.007	0.1	0.1	-0.2	0.3	0.1	0.1	-0.2	0.3
Tomatoes, fresh	15.400	76.0	60.6	224.6	-164.0	-70.9	-86.3	70.3	-156.6
Subtotal	16.502	46.3	29.8	299.8	-270.0	-111.0	-127.5	135.0	-262.5
Tobacco									
Field transplanted	0.000	107.7	107.7	228.0	-120.3	-93.0	-93.0	23.1	-116.1
Plant bed	5.088	0.0	-5.1	0.0	-5.1	0.0	-5.1	0.0	-5.1
Subtotal	5.088	107.7	102.6	228.0	-125.4	-93.0	-98.1	23.1	-121.2
Total, 15 crops	18.632	151.8	133.1	558.8	-425.7	-206.2	-224.9	189.1	-414.0
Crops with losses valued using constant market prices \a:									
Cucumbers	0.000	--	--	--	-72.1	--	--	--	-72.1
Eggplant	-0.408	--	--	--	-11.8	--	--	--	-11.8
Melons	-1.200	--	--	--	-28.5	--	--	--	-28.5
Peppers	3.585	--	--	--	-130.7	--	--	--	-130.7
Ornamentals	13.282	--	--	--	-163.4	--	--	--	-163.4
Forest Seedlings	0.208	--	--	--	-35.0	--	--	--	-35.0
Total, 6 crops	15.467	--	--	--	-441.5	--	--	--	-441.5
Total, selected crops	34.099	--	--	--	-867.2	--	--	--	-855.5

\a For these crops, the estimates of "total impact" reflect the change in cost (first column above) plus the "value" of production loss (below). Value of production loss is derived using constant market price, as follows:

	Price/ton (Dollars)	Production loss (tons)	Value (Mil. dol.)
Cucumbers	381	189,150	72.1
Eggplant	466	26,200	12.2
Melons	320	92,750	29.7
Peppers	569	223,351	127.1
Ornamentals	*	*	150.1
Forest seedling	*	*	34.8
		Total	426.0

* Price/ton, production loss, and value of ornamental- and forest seedling-loss estimates are from biological section. [Value-of-loss formula used: (((Number of seedlings x acres treated) x (percent yield loss)) x price per seedling) + adjustments, e.g., unplanted acres, etc.].

Table 3b. Without Vorlex: Projected Effects of methyl bromide Ban With and Without Imports, Growers and Consumers

Crop	Without imports: Change in growers': Control cost	Revenue	Net revenue	Change in consumer cost	Total impact	With imports: Change in growers': Revenue	Net revenue	Change in consumer cost	Total impact
	Million dollars								
Crops with losses valued using projected market prices:									
Fruits\nuts:									
Almonds	-0.856	0.3	1.2	0.5	0.7	0.3	1.2	0.5	0.7
Apples	-0.038	0.4	0.4	0.8	-0.4	0.4	0.4	0.8	-0.4
Apricots	-0.002	0.0	0.0	0.2	-0.2	0.0	0.0	0.2	-0.2
Cherries	-0.006	0.7	0.7	0.4	0.3	0.7	0.7	0.4	0.3
Citrus	-0.490	-6.4	-5.9	18.6	-24.5	-6.4	-5.9	18.6	-24.5
Grapes	-1.210	1.8	3.0	6.2	-3.2	1.8	3.0	6.2	-3.2
Nectarines	-0.109	0.1	0.2	1.1	-0.9	0.1	0.2	1.1	-0.9
Peaches	-0.218	0.1	0.3	1.1	-0.8	0.1	0.3	1.1	-0.8
Plums/prunes	-0.019	0.1	0.1	0.5	-0.4	0.1	0.1	0.5	-0.4
Walnuts	-0.012	0.7	0.7	1.6	-0.9	0.7	0.7	1.6	-0.9
Subtotal	-2.959	-2.2	0.7	31.0	-30.3	-2.2	0.7	31.0	-30.3
Vegetables:									
Carrots	0.003	0.0	0.0	-0.3	0.3	0.0	0.0	-0.3	0.3
Strawberries	0.829	-31.9	-32.7	78.9	-111.6	-42.6	-43.4	68.0	-111.4
Sweet potatoes	0.007	0.1	0.1	-0.2	0.3	0.1	0.1	-0.2	0.3
Tomatoes, fresh	7.856	89.6	81.7	442.5	-360.8	-172.7	-180.6	146.8	-327.4
Subtotal	8.694	57.8	49.1	520.9	-471.8	-215.2	-223.9	214.3	-438.2
Tobacco									
Field transplanted	0.000	108.5	108.5	229.9	-121.4	-93.8	-93.8	23.3	-117.1
Plant bed	5.088	0.0	-5.1	0.0	-5.1	0.0	-5.1	0.0	-5.1
Subtotal	5.088	108.5	103.4	229.9	-126.5	-93.8	-98.9	23.3	-122.2
Total, 15 crops	10.824	164.1	153.2	781.8	-628.6	-311.2	-322.1	268.6	-590.7
Crops with losses valued using constant market prices \a:									
Cucumbers	0.000	--	--	--	-72.1	--	--	--	-72.1
Eggplant	-0.408	--	--	--	-11.8	--	--	--	-11.8
Melons	-1.121	--	--	--	-28.6	--	--	--	-28.6
Peppers	1.471	--	--	--	-135.3	--	--	--	-135.3
Ornamentals	15.445	--	--	--	-170.0	--	--	--	-170.0
Forest Seedlings	0.208	--	--	--	-35.0	--	--	--	-35.0
Total, 6 crops	15.595	--	--	--	-452.8	--	--	--	-452.8
Total, selected crops	26.418	--	--	--	-1,081.4	--	--	--	-1,043.5

\a For these crops, the estimates of "total impact" reflect the change in cost (first column above) plus the "value" of production loss (below). Value of production loss is derived using constant market price, as follows:

	Price/ton (Dollars)	Production loss (tons)	Value (Mil. dol.)
Cucumbers	381	189,150	72.1
Eggplant	466	26,200	12.2
Melons	320	92,750	29.7
Peppers	569	235,140	133.9
Ornamentals	*	*	154.6
Forest seedling	*	*	34.8
		Total	437.2

* Price/ton, production loss, and value of ornamental- and forest seedling-loss estimates are from biological section. [Value-of-loss formula used: (((Number of seedlings x acres treated) x (percent yield loss)) x price per seedling) + adjustments, e.g., unplanted acres, etc.].

Table 4. Production Acres, Selected Crops, 1990-91

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected states
			Production acres			
Fruits\nuts:						
Almonds	430,000	—	—	—	—	430,000
Apples	32,600	—	—	—	—	32,600
Apricots	19,303	—	—	—	—	19,303
Cherries	12,000	—	—	—	—	12,000
Citrus	250,600	555,700	—	—	—	806,300
Grapes	779,400	—	1,700	600	340	782,040
Nectarines	29,100	—	—	—	—	29,100
Peaches	68,786	—	20,000	4,200	31,800	124,786
Plums/prunes	105,700	—	—	—	—	105,700
Walnuts	181,000	—	—	—	—	181,000
Vegetables:						
Carrots	56,000	—	—	—	—	56,000
Cucumbers	4,700	17,100	—	25,000	10,800	57,600
Eggplant	—	2,050	—	—	—	2,050
Melons	106,400	53,000	6,000	3,982	2,200	171,582
Peppers	23,700	23,100	5,000	6,718	—	58,518
Strawberries	19,500	5,400	—	2,000	1,100	28,000
Sweet potatoes	8,300	—	5,000	35,500	33,500	82,300
Tomatoes, fresh	38,000	55,800	3,100	3,387	4,000	104,287
Miscellaneous crops:						
Tobacco \a						
Field transplanted	—	6,767	41,500	289,000	49,500	558,050
Plant bed	—	—	850	4,566	1,000	10,416
Ornamentals	50,000	1,782	—	1,500	—	53,282
Forest seedlings	150	138	798	150	210	1,446

-- = no commercial production acreage reported.

\a Selected states total for tobacco include Kentucky's 178,050 production acres and 4,000 plant bed acres.

Table 5. Methyl bromide-Treated Acres, Selected Crops, 1990-91

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected states
			Acres treated			
Fruits\nuts:						
Almonds	1,803	—	—	—	—	1,803
Apples	450	—	—	—	—	450
Apricots	75	—	—	—	—	75
Cherries	224	—	—	—	—	224
Citrus	N.A.	—	—	—	—	0
Grapes	4,838	—	—	—	—	4,838
Nectarines	791	—	—	—	—	791
Peaches	1,586	—	—	—	—	1,586
Plums/prunes	740	—	—	—	—	740
Walnuts	481	—	—	—	—	481
Vegetables:						
Carrots	9	—	—	—	—	9
Cucumbers \a	0	—	—	—	—	0
Eggplant	—	2,050	—	—	—	2,050
Melons	559	10,600	1,800	380	990	14,329
Peppers	594	19,635	1,000	739	—	21,968
Strawberries	17,306	5,346	—	660	737	24,049
Sweet potatoes	45	—	—	—	—	45
Tomatoes, fresh	592	54,684	2,790	1,400	4,000	63,466
Miscellaneous crops:						
Tobacco						
Field transpla	—	6,767	41,500	289,000	49,500	386,767
Plant bed \b	—	—	850	4,475	950	8,275
Ornamentals	6,204	1,493	—	1,350	—	9,047
Forest seedlings	18	138	399	100	210	865

\a Estimated 1,700 acres of cucumbers double-cropped with methyl bromide-treated tomatoes or peppers.
\b Selected States total for tobacco includes 2,000 methyl bromide-treated plant bed acres in Kentucky.

Table 6. Proportion of Crop's Planted Acres Treated With Methyl bromide, 1990-91

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected states
	Acres treated (% of planted acres)					
Fruits\nuts:						
Almonds	0.4%	--	--	--	--	0.4%
Apples	1.4%	--	--	--	--	1.4%
Apricots	0.4%	--	--	--	--	0.4%
Cherries	1.9%	--	--	--	--	1.9%
Citrus	--	--	--	--	--	--
Grapes	0.6%	--	--	--	--	0.6%
Nectarines	2.7%	--	--	--	--	2.7%
Peaches	2.3%	--	--	--	--	1.3%
Plums/prunes	0.7%	--	--	--	--	0.7%
Walnuts	0.3%	--	--	--	--	0.3%
Vegetables:						
Carrots	0.0%	--	--	--	--	0.0%
Cucumbers \a	--	--	--	--	--	--
Eggplant	--	100.0%	--	--	--	100.0%
Melons	0.5%	20.0%	30.0%	9.5%	45.0%	8.4%
Peppers	2.5%	85.0%	20.0%	11.0%	--	37.5%
Strawberries	88.7%	99.0%	--	33.0%	67.0%	85.9%
Sweet potatoes	0.5%	--	--	--	--	0.1%
Tomatoes, fresh	1.6%	98.0%	90.0%	41.3%	100.0%	60.9%
Field crops:						
Tobacco						
Plant bed \b	--	--	100.0%	98.0%	95.0%	69.3%
Ornamentals	12.4%	83.8%	--	90.0%	--	79.4%
Forest seedlings	12.0%	100.0%	50.0%	66.7%	100.0%	17.0%

\a Estimated 1,700 acres of Florida cucumbers double-cropped with methyl bromide-treated tomatoes or peppers.
\b Selected States total for tobacco includes 2,000 methyl bromide-treated plant bed acres in Kentucky.

Table 7a. With Vorlex: Per Acre Change in Control Cost Using Methyl bromide Alternatives

Crop	California	Florida	Georgia	North Carolina	South Carolina
			Dollars		
Fruits\nuts:					
Almonds	-475	--	--	--	--
Apples	-85	--	--	--	--
Apricots	-25	--	--	--	--
Cherries	-25	--	--	--	--
Citrus	--	--	--	--	--
Grapes	-250	--	--	--	--
Nectarines	-138	--	--	--	--
Peaches	-138	--	--	--	--
Plums/prunes	-25	--	--	--	--
Walnuts	-25	--	--	--	--
Vegetables:					
Carrots	300	--	--	--	--
Cucumbers \a	--	--	--	--	--
Eggplant	--	-199	--	--	--
Melons	-75	-107	91	91	-200
Peppers	-75	191	-161	91	--
Strawberries	50	125	--	-175	-485
Sweet potatoes	154	--	--	--	--
Tomatoes, fresh	-675	299	-245	91	-12
Misc. crops:					
Tobacco					
Field transplanted	--	--	--	--	--
Plant bed \b	--	--	385	876	959
Ornamentals	-159	6,314	--	3,588	0
Forest Seedlings	-396	58	-250	28	1,450

\a Methyl bromide control is from other crops double cropped with cucumbers.

\b In Kentucky, the cost of using methyl bromide and alternatives Vorlex and metam-sodium is an estimated $1,000 per acre; thus, there would be no change in control cost.

Table 7b. Without Vorlex: Per Acre Change in Control Cost Using Methyl bromide Alternatives

Crop	California	Florida	Georgia	North Carolina	South Carolina
			Dollars		
Fruits\nuts:					
Almonds	-475	--	--	--	--
Apples	-85	--	--	--	--
Apricots	-25	--	--	--	--
Cherries	-25	--	--	--	--
Citrus	--	--	--	--	--
Grapes	-250	--	--	--	--
Nectarines	-138	--	--	--	--
Peaches	-138	--	--	--	--
Plums/prunes	-25	--	--	--	--
Walnuts	-25	--	--	--	--
Vegetables:					
Carrots	300	--	--	--	--
Cucumbers \a	--	--	--	--	--
Eggplant	--	-199	--	--	--
Melons	-75	-107	116	116	-200
Peppers	-75	66	134	116	--
Strawberries	50	82	--	-175	-485
Sweet potatoes	154	--	--	--	--
Tomatoes, fresh	-675	132	-100	116	285
Misc. crops:					
Tobacco					
Field transplanted	--	--	--	--	--
Plant bed	--	--	330	876	932
Ornamentals	-159	7,763	--	3,588	0
Forest Seedlings	-396	58	-250	28	1,450

\a Methyl bromide control is from other crops double cropped with cucumbers.

Table 8a. With Vorlex: Total Change in Control Cost Using Methyl bromide Alternatives

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected states
			Million dollars			
Fruits\nuts:						
Almonds	-0.9	--	--	--	--	-0.9
Apples	-0.0	--	--	--	--	-0.0
Apricots	-0.0	--	--	--	--	-0.0
Cherries	-0.0	--	--	--	--	-0.0
Citrus \a	--	-0.5	--	--	--	-0.5
Grapes	-1.2	--	--	--	--	-1.2
Nectarines	-0.1	--	--	--	--	-0.1
Peaches	-0.2	--	--	--	--	-0.2
Plums/prunes	-0.0	--	--	--	--	-0.0
Walnuts	-0.0	--	--	--	--	-0.0
Subtotal	-2.5	-0.5	0.0	0.0	0.0	-3.0
Vegetables:						
Carrots	0.0	--	--	--	--	0.0
Cucumbers	--	--	--	--	--	0.0
Eggplant	--	-0.4	--	--	--	-0.4
Melons	-0.0	-1.1	0.2	0.0	-0.2	-1.2
Peppers	-0.0	3.7	-0.2	0.1	--	3.6
Strawberries	0.9	0.7	--	-0.1	-0.4	1.1
Sweet potatoes	0.0	--	--	--	--	0.0
Tomatoes, fresh	-0.4	16.4	-0.7	0.1	0.0	15.4
Subtotal	0.4	19.3	-0.7	0.1	-0.6	18.5
Tobacco						
Plant bed	--	--	0.3	3.9	0.9	5.1
Ornamentals	-1.0	9.4	--	4.8	--	13.3
Forest Seedlings	-0.0	0.0	-0.1	0.0	0.3	0.2
Total	-3.0	28.2	-0.5	8.9	0.6	34.1

\a Methyl bromide was used to post-harvest treat 4,080 trucks at a cost of $120 per truck.

Table 8b. Without Vorlex: Total Change in Control Cost Using Methyl bromide Alternatives

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected states
			Million dollars			
Fruits\nuts:						
Almonds	-0.9	--	--	--	--	-0.9
Apples	-0.0	--	--	--	--	-0.0
Apricots	-0.0	--	--	--	--	-0.0
Cherries	-0.0	--	--	--	--	-0.0
Citrus \a	--	-0.5	--	--	--	-0.5
Grapes	-1.2	--	--	--	--	-1.2
Nectarines	-0.1	--	--	--	--	-0.1
Peaches	-0.2	--	--	--	--	-0.2
Plums/prunes	-0.0	--	--	--	--	-0.0
Walnuts	-0.0	--	--	--	--	-0.0
Subtotal	-2.5	-0.5	0.0	0.0	0.0	-3.0
Vegetables:						
Carrots	0.0	--	--	--	--	0.0
Cucumbers	--	--	--	--	--	0.0
Eggplant	--	-0.4	--	--	--	-0.4
Melons	-0.0	-1.1	0.2	0.0	-0.2	-1.1
Peppers	-0.0	1.3	0.1	0.1	--	1.5
Strawberries	0.9	0.4	--	-0.1	-0.4	0.8
Sweet potatoes	0.0	--	--	--	--	0.0
Tomatoes, fresh	-0.4	7.2	-0.3	0.2	1.1	7.9
Subtotal	0.4	7.4	0.1	0.2	0.6	8.6
Tobacco						
Plant bed	--	--	0.3	3.9	0.9	5.1
Ornamentals	-1.0	11.6	--	4.8	--	15.4
Forest Seedlings	-0.0	0.0	-0.1	0.0	0.3	0.2
Total	-3.1	18.5	0.2	8.9	1.8	26.4

\a Methyl bromide was used to post-harvest treat 4,080 trucks at a cost of $120 per truck.

Table 9a. With Vorlex: Production Loss Using Methyl bromide Alternatives

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected States
			1,000 tons			
Fruits\nuts:						
Almonds	0.077	—	—	—	—	0.077
Apples	2.106	—	—	—	—	2.106
Apricots	0.158	—	—	—	—	0.158
Cherries	0.126	—	—	—	—	0,126
Citrus \a	—	76.000	—	—	—	76.000
Grapes	13.061	—	—	—	—	13.061
Nectarines	2.009	—	—	—	—	2.009
Peaches	3.965	—	—	—	—	3.965
Plums/prunes	1.554	—	—	—	—	1.554
Walnuts	0.501	—	—	—	—	0.501
Vegetables:						
Carrots	0.014	—	—	—	—	0.014
Cucumbers	—	189.150	—	—	—	189.150
Eggplant	—	26.200	—	—	—	26.200
Melons	4.366	84.800	0.411	0.023	3.150	92.750
Peppers	7.[illegible]25	191.244	22.950	1.732	—	223.351
Strawberries	65.415	37.382	—	0.832	1.180	104.809
Sweet potatoes	0.118	—	—	—	—	0.118
Tomatoes, fresh	5.147	161.885	16.740	10.220	21.000	214.972
Field crops:						
Tobacco						
Field transplanted	—	—	4.752	29.512	—	34.264
Plant bed	—	—	—	—	—	—
Ornamentals	\b	\b	\b	\b	\b	\b
Forest Seedlings	\b	\b	\b	\b	\b	\b

\a Refers to loss of citrus transported in methyl bromide-fumigated trucks.
\b See biological section for loss of production (in millions of plants).

Table 9b. Without Vorlex: Production Loss Using Methyl bromide Alternatives

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected States
			1,000 tons			
Fruits\nuts:						
Almonds	0.077	—	—	—	—	0.077
Apples	2.106	—	—	—	—	2.106
Apricots	0.158	—	—	—	—	0.158
Cherries	0.126	—	—	—	—	0.126
Citrus \a	—	76.000	—	—	—	76.000
Grapes	13.061	—	—	—	—	13.061
Nectarines	2.009	—	—	—	—	2.009
Peaches	3.965	—	—	—	—	3.965
Plums/prunes	1.554	—	—	—	—	1.554
Walnuts	0.501	—	—	—	—	0.501
Vegetables:						
Carrots	0.014	—	—	—	—	0.014
Cucumbers	—	189.150	—	—	—	189.150
Eggplant	—	26.200	—	—	—	26.200
Melons	4.366	84.800	0.411	0.023	3.150	92.750
Peppers	7.425	201.965	22.950	2.800	—	235.140
Strawberries	65.415	42.225	—	0.832	1.180	109.652
Sweet potatoes	0.118	—	—	—	—	0.118
Tomatoes, fresh	5.147	404.661	16.740	10.220	21.000	457.768
Field crops:						
Tobacco						
Field transplanted	—	—	5.040	29.512	—	34.552
Plant bed	—	—	—	—	—	—
Ornamentals	\b	\b	\b	\b	\b	\b
Forest Seedlings	\b	\b	\b	\b	\b	\b

\a Refers to loss of citrus transported in methyl bromide-fumigated trucks.
\b See biological section for loss of production (in millions of plants).

Table 10a. With Vorlex: Production Loss as a Proportion of Total Crop

Crop	California	Florida	Georgia	North Carolina	South Carolina
Fruits\nuts	Yield loss as proportion of total crop \a				
Almonds	0%	--	--	--	--
Apples	1%	--	--	--	--
Apricots	0%	--	--	--	--
Cherries	0%	--	--	--	--
Citrus \b	--	1%	--	--	--
Grapes	0%	--	--	--	--
Nectarines	1%	--	--	--	--
Peaches	0%	--	--	--	--
Plums/prunes	0%	--	--	--	--
Walnuts	0%	--	--	--	--
Vegetables					
Carrots	0%	--	--	--	--
Cucumbers	--	100%	--	--	--
Eggplant	--	100%	--	--	--
Melons	1%	23%	1%	0%	3%
Peppers	3%	85%	30%	3%	--
Strawberries	14%	59%	--	12%	31%
Sweet potatoes	0%	--	--	--	--
Tomatoes, fresh	1%	19%	45%	81%	31%
Field crops:					
Tobacco					
Field transplanted	--	--	10%	10%	--
Plant bed	--	--	--	--	--
Ornamentals	\c	\c	\c	\c	\c
Forest Seedlings	\c	\c	\c	\c	\c

\a Based on yield losses indicated in biological section as a proportion of 1989-91 production.
\b Refers to loss of citrus transported in methyl bromide-fumigated trucks.
\c See biological section.

Table 10b. Without Vorlex: Production Loss as a Proportion of Total Crop

Crop	California	Florida	Georgia	North Carolina	South Carolina
Fruits\nuts	Yield loss as proportion of total crop \a				
Almonds	0%	--	--	--	--
Apples	1%	--	--	--	--
Apricots	0%	--	--	--	--
Cherries	0%	--	--	--	--
Citrus \b	--	1%	--	--	--
Grapes	0%	--	--	--	--
Nectarines	1%	--	--	--	--
Peaches	0%	--	--	--	--
Plums/prunes	0%	--	--	--	--
Walnuts	0%	--	--	--	--
Vegetables					
Carrots	0%	--	--	--	--
Cucumbers	--	100%	--	--	--
Eggplant	--	100%	--	--	--
Melons	1%	23%	1%	0%	3%
Peppers	3%	90%	30%	5%	--
Strawberries	14%	67%	--	12%	31%
Sweet potatoes	0%	--	--	--	--
Tomatoes, fresh	1%	46%	45%	81%	31%
Field crops:					
Tobacco					
Field transplanted	--	--	11%	10%	--
Plant bed	--	--	--	--	--
Ornamentals	\c	\c	\c	\c	\c
Forest Seedlings	\c	\c	\c	\c	\c

\a Based on yield losses indicated in biological section as a proportion of 1989-91 production.
\b Refers to loss of citrus transported in methyl bromide-fumigated trucks.
\c See biological section.

Table 11a. With Vorlex: Projected Short-term Prices with Change in Production, With and Without Imports

Crop	Base price/ ton, U.S.	Elasticity of demand	Projected price with:		Change in price\b \c	
			No imports	Imports\a	No imports	Imports
	Dollars/ton	Coefficient	Dollars/ton			
Fruits\nuts:						
Almonds	2,005	-0.3300	2,007	2,007	2 (0%)	2 (0%)
Apples	289	-0.6700	289	289	0 (0%)	0 (0%)
Apricots	358	-0.2357	360	360	2 (1%)	2 (1%)
Cherries	843	-0.2357	844	844	1 (0%)	1 (0%)
Citrus	301	-1.3780	303	303	2 (1%)	2 (1%)
Grapes	307	-0.7000	308	308	1 (0%)	1 (0%)
Nectarines	482	-0.9000	487	487	5 (1%)	5 (1%)
Peaches	330	-0.9000	331	331	1 (0%)	1 (0%)
Plums/prunes	317	-0.7000	318	318	1 (0%)	1 (0%)
Walnuts	1,040	-0.3300	1,047	1,047	7 (1%)	7 (1%)
Vegetables:						
Carrots	202	-0.5200	202	202	0 (0%)	0 (0%)
Strawberries	944	-1.2000	1,074	1,055	130(14%)	111(12%)
Sweet potatoes	258	-0.4070	258	258	0 (0%)	0 (0%)
Tomatoes, fresh	623	-0.5580	763	665	140(22%)	42 (7%)
Field crop:						
Tobacco	3,404	-0.5000	3,704	3,434	300 (9%)	30 (1%)

a/ Assumes a proportion of production loss offset by imports in short-term for strawberries (15%), tomatoes (70%), and tobacco (90%).
b/ "Projected price" minus "base price."
c/ Information not available to project prices of cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings.

Table 11b. Without Vorlex: Projected Short-term Prices with Change in Production, With and Without Imports

Crop	Base price/ ton, U.S.	Elasticity of demand	Projected price with: No imports	Projected price with: Imports\a	Change in price\b \c No imports	Change in price\b \c Imports
	Dollars/ton	Coefficient	Dollars/ton		Dollars/ton	
Fruits\nuts:						
Almonds	2,005	-0.3300	2,007	2,007	2 (0%)	2 (0%)
Apples	289	-0.6700	289	289	0 (0%)	0 (0%)
Apricots	358	-0.2357	360	360	2 (1%)	2 (1%)
Cherries	843	-0.2357	844	844	1 (0%)	1 (0%)
Citrus	301	-1.3780	303	303	2 (1%)	2 (1%)
Grapes	307	-0.7000	308	308	1 (0%)	1 (0%)
Nectarines	482	-0.9000	487	487	5 (1%)	5 (1%)
Peaches	330	-0.9000	330	330	0 (0%)	0 (0%)
Plums/prunes	317	-0.7000	318	318	1 (0%)	1 (0%)
Walnuts	1,040	-0.3300	1,047	1,047	7 (1%)	7 (1%)
Vegetables:						
Carrots	202	-0.5200	202	202	0 (0%)	0 (0%)
Strawberries	944	-1.2000	1,080	1,060	136(14%)	116(12%)
Sweet potatoes	258	-0.4070	258	258	0 (0%)	0 (0%)
Tomatoes, fresh	623	-0.5580	920	712	297(48%)	89(14%)
Tobacco	3,404	-0.5000	3,707	3,434	303 (9%)	30 (1%)

a/ Assumes a proportion of production loss offset by imports in short-term for strawberries (15%), tomatoes (70%), and tobacco (90%).
b/ "Projected price" minus "base price."
c/ Information not available to project prices of cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings.

Table 1: Fruits and Vegetables Requiring Methyl Bromide Fumigation or an Alternative Treatment as a Condition of Entry

COMMODITY[1]	COUNTRY
APPLE	**METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** CHILE, ECUADOR, ISRAEL
APRICOT	**METHYL BROMIDE FUMIGATION REQUIRED:** CHILE **METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** ISRAEL, MOROCCO
ASPARAGUS	**METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** AUSTRALIA
AVOCADO	**METHYL BROMIDE FUMIGATION REQUIRED:** BERMUDA, ISRAEL, PHILIPPINES
BEANS[2,3]	**METHYL BROMIDE FUMIGATION REQUIRED:** ANTIGUA, ARUBA, BAHAMAS, BARBADOS, BELIZE, CAYMAN ISLANDS, COSTA RICA, DOMINICA, DOMINICAN REPUBLIC, ECUADOR, GRENADA, GUADELOUPE, HAITI, HONDURAS, JAMAICA, MARTINIQUE, MONTSERRAT, ST. CHRISTOPHER, ST. BARTHELEMY, ST. LUCIA, ST. VINCENT/GRENADINES, SENEGAL, VENEZUELA
BRASSICA OLERACEAE	**METHYL BROMIDE FUMIGATION REQUIRED:** ISRAEL, JAPAN
CHERRIES	**METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** CHILE
CIPOLLINO	**METHYL BROMIDE FUMIGATION REQUIRED:** MOROCCO
ETHROG	**METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** ALBANIA, ALGERIA, CORSICA, CYPRUS, ECUADOR, EL SALVADOR, FRANCE, GREECE, GUATEMALA, HONDURAS, ISRAEL, ITALY, MOROCCO, PANAMA, PORTUGAL, SPAIN, SYRIA, TUNISIA, TURKEY, YUGOSLAVIA
GARLIC[4]	**METHYL BROMIDE FUMIGATION REQUIRED:** ALGERIA, AUSTRIA, CZECHOSLOVAKIA, EGYPT, ESTONIA, FRANCE, GERMANY, GREECE, HUNGARY, ISRAEL, LATVIA, LITHUANIA, LEBANON, MOROCCO, PORTUGAL, SPAIN, SWITZERLAND, SYRIA, TURKEY, USSR, YUGOSLAVIA, **METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** ITALY
GRAPE	**METHYL BROMIDE FUMIGATION REQUIRED:** ALGERIA, ARGENTINA, AUSTRIA, BULGARIA, CHILE, CYPRUS, EGYPT, ESTONIA, GERMANY, GREECE, HUNGARY, ISRAEL, ITALY, LATVIA, LITHUANIA, LUXEMBOURG, MOROCCO, PORTUGAL, SPAIN, SWITZERLAND, SYRIA, TUNISIA, USSR, URUGUAY **METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** FRANCE
GRAPEFRUIT	**METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** MEXICO
HORSERADISH[5]	**METHYL BROMIDE FUMIGATION REQUIRED:** ALBANIA, AUSTRIA, BELGIUM, BULGARIA, CHILE, CZECHOSLOVAKIA, DENMARK, ESTONIA, FINLAND, FRANCE, GERMANY, GREAT BRITAIN, GREECE, HUNGARY, ISRAEL, ITALY, JAPAN, LATVIA, LITHUANIA, MEXICO, NETHERLANDS, NORTHERN IRELAND, NORWAY, POLAND, PORTUGAL, ROMANIA, SPAIN, SWEDEN, SWITZERLAND, TAIWAN, USSR, YUGOSLAVIA
KIWI FRUIT	**METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** FRANCE, ITALY
LEMON	**METHYL BROMIDE FUMIGATION REQUIRED:** CHILE
NECTARINE	**METHYL BROMIDE FUMIGATION REQUIRED:** CHILE **METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** ISRAEL

TABLE 1 (CONTINUED): FRUITS AND VEGETABLES REQUIRING METHYL BROMIDE FUMIGATION OR AN ALTERNATIVE TREATMENT AS A CONDITION OF ENTRY

COMMODITY[1]	COUNTRY
OKRA[6]	**METHYL BROMIDE FUMIGATION REQUIRED:** ANTIGUA, BAHAMAS, BARBADOS, BRAZIL, CAYMAN ISLANDS, COLOMBIA, DOMINICA, DOMINICAN REPUBLIC, ECUADOR, GRENADA, GUADELOUPE, HAITI, JAMAICA, MARTINIQUE, MEXICO, MONTSERRAT, PERU, ST. CHRISTOPHER, ST. BARTHELEMY, ST. EUSTATIUS, ST. LUCIA, ST. MARTIN, ST. VINCENT/GRENADINES, TRINIDAD/TOBAGO, VENEZUELA, VIRGIN ISLANDS (BR)
ORANGE	**METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** MEXICO
PEACH	**METHYL BROMIDE FUMIGATION REQUIRED:** CHILE **METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** ISRAEL, MOROCCO, TUNISIA
PEAR	**METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** ALGERIA, CHILE, EGYPT, ISRAEL, MOROCCO, TUNISIA
PEAS	**METHYL BROMIDE FUMIGATION REQUIRED:** BELGIUM, EGYPT, ISRAEL, ITALY, NICARAGUA
PIGEON PEAS[3]	**METHYL BROMIDE FUMIGATION REQUIRED:** ANTIGUA, BAHAMAS, BARBADOS, BELIZE, CAYMAN ISLANDS, COSTA RICA, DOMINICA, DOMINICAN REPUBLIC, ECUADOR, GRENADA, GUADELOUPE, HAITI, JAMAICA, MARTINIQUE, MONTSERRAT, ST.
PLUM	CHRISTOPHER, ST. BARTHELEMY, ST. LUCIA, ST. VINCENT/GRENADINES, VENEZUELA
QUINCE	**METHYL BROMIDE FUMIGATION REQUIRED:** CHILE **METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** ALGERIA,
ROSELLE	ISRAEL, MOROCCO, TUNISIA
	METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED: CHILE
	METHYL BROMIDE FUMIGATION REQUIRED: TRINIDAD/TOBAGO

COMMODITY[1]	COUNTRY
TANGERINE	**METHYL BROMIDE FUMIGATION OR ALTERNATIVE TREATMENT REQUIRED:** MEXICO
THYME	**METHYL BROMIDE FUMIGATION REQUIRED:** JAMAICA
TUNA (FRUIT)	**METHYL BROMIDE FUMIGATION REQUIRED:** COLOMBIA, ITALY
YAM	**METHYL BROMIDE FUMIGATION REQUIRED:** ALBANIA, ALGERIA, ANGOLA, ANGUILLA, ANTIGUA, ARGENTINA, ARUBA, AUSTRALIA, AUSTRIA, AZORES, BAHAMAS, BARBADOS, BELGIUM, BELIZE, BENIN, BERMUDA, BOLIVIA, BRAZIL BULGARIA, BURKINA FASO, CAMEROON, CANARY ISLANDS, CAYMAN ISLANDS, CHANNEL ISLANDS, CHILE, CHINA, COLOMBIA, REP. OF CONGO, CORSICA, COSTA RICA, COTE D'IVOIRE, CURACAO, CYPRUS, CZECHOSLOVAKIA, DENMARK DOMINICA, DOMINICAN REPUBLIC, ECUADOR, EGYPT, EL SALVADOR, ESTONIA, FIJI, FINLAND, FRANCE, FRENCH GUIANA, FRENCH POLYNESIA, GABON, GERMANY, GHANA, GREAT BRITAIN, GREECE, GRENADA, GUADELOUPE, GUATEMALA, GUINEA, GUYANA, HAITI, HONDURAS, HONG KONG, HUNGARY, ICELAND, INDIA, INDONESIA, IRELAND, ISRAEL, ITALY, JAMAICA, JAPAN, REP. OF KOREA, LATVIA, LEBANON, LIBERIA, LUXEMBOURG, MADAGASCAR, MADEIRA ISLANDS, MALAYSIA, MALI, MARIANA ISLANDS, MARTINIQUE, MAURITANIA, MEXICO, MICRONESIA, MONTSERRAT, MOROCCO, NETHERLANDS, NEW ZEALAND, NICARAGUA, NIGER, NIGERIA, NORTHERN IRELAND, NORWAY, PAKISTAN, PALAU, PANAMA, PAPUA, NEW GUINEA, PARAGUAY, PERU, PHILIPPINES, POLAND, PORTUGAL, RHODES (ISLAND), ROMANIA, SAMOA (WESTERN), SENEGAL, SPAIN, SRI LANKA, ST. BARTHELEMY, ST. CHRISTOPHER, ST. EUSTATIUS, ST. LUCIA, ST. MARTIN, ST. VINCENT/GRENADINES, SIERRA LEONE, SURINAME, SWEDEN, SWITZERLAND, SYRIA, TAIWAN, TANZANIA, THAILAND, TOGO, TONGA, TRINIDAD/TOBAGO, TUNISIA, TURKEY, URUGUAY, USSR, VANUATU, VENEZUELA, VIRGIN ISLANDS (BR), VOLCANO ISLANDS, YUGOSLAVIA

Source: USDA, APHIS, PPQ. Plant Import: Nonpropagative.

1 Excludes dasheen and sweetpotatoes. Dasheen is enterable only to Guam and Commonwealth of the Northern Mariana Islands; sweetpotatoes are enterable only to the Virgin Islands and Puerto Rico.
2 Includes string beans, garden beans, lima beans, hyacinth beans, lablab beans, and winged beans. Not all of these individual beans require methyl bromide fumigation from each of the countries listed.
3 Methyl bromide fumigation is required only if the product is destined to South Atlantic and Gulf ports..
4 Includes bulb.
5 Includes horseradish root. Horseradish from many of these countries requires methyl bromide fumigation only when entering Hawaii.
6 Methyl Bromide fumigation is required only if the product is destined to South Atlantic and Gulf ports or certain other states.

Table 2: Other Food Imports Requiring Methyl Bromide Fumigation or an Alternative Treatment as a Condition of Entry

Commodity	Description and Country	Commodity	Description and Country
Chestnuts	**Unprocessed or Shelled Nuts** all countries except Canada and Mexico	Dasheen	**Unprocessed, sliced, or pellets** Costa Rica, Dominican Republic, Honduras, Jamaica, Samoa, Tonga
Curcurbit Seeds - Cucumber, Melon, Pumpkin, Squash	**Unprocessed, dried, roasted or salted seeds:** Afghanistan, Algeria, Bangladesh, Burkina Faso, Cyprus, Egypt, India, Iran, Iraq, Israel, Libya, Mali, Mauritania, Morocco, Myanmar, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, Turkey	Faba Bean	**Unprocessed seeds** All countries except Canada, Central America, Mexico, or West Indies
		Lentils	**Unprocessed seeds** All countries except Canada, Central America, Mexico, or West Indies
Cumin	**Unprocessed, roasted, or ground seeds** If bagged in Jute or Burlap - Afghanistan, Algeria, Bangladesh, Burkina Faso, Cyprus, Egypt, India, Iran, Iraq, Israel, Libya, Mali, Mauritania, Morocco, Myanmar, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, Turkey	Peppers	**Dried** If bagged in Jute or Burlap - Afghanistan, Algeria, Bangladesh, Burkina Faso, Cyprus, Egypt, India, Iran, Iraq, Israel, Libya, Mali, Mauritania, Morocco, Myanmar, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, Turkey

Source: USDA, APHIS, PPQ. Plant Import: Nonpropagative.

Table 3: Nonfood Imports Requiring Methyl Bromide Fumigation or an Alternative Treatment as a Condition of Entry

Commodity	Description and Country	Commodity	Description and Country
Acorn	**Unprocessed nuts for analytical, industrial, or other nonfood use** All countries except Canada or Mexico	Brassware	**Any Packing Material -** India **If burlap or jute -** Afghanistan, Algeria, Bangladesh, Burkina Faso, Burma, Cyprus, Egypt, India, Iran, Israel, Libya, Mali, Mauritania, Morocco, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, Turkey
Bags, Bagging, or Covers: Used	**That held or covered cotton:** **If Burlap or Jute -** Afghanistan, Algeria, Bangladesh, Burkina Faso, Burma, Cyprus, Egypt, India, Iran, Iraq, Israel, Libya, Mali, Mauritania, Morocco, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, Turkey **If other Material -** All countries under certain conditions	Broomcorn	All Countries
	That held or covered fresh or frozen meat: **If burlap or jute -** Afghanistan, Algeria, Bangladesh, Burkina Faso, Burma, Cyprus, Egypt, India, Israel, Libya, Mali, Mauritania, Morocco, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, Turkey	Broomstraw	All countries except Canada
	That held or covered wheat or wheat products: **If burlap or jute -** Burkina Faso, Burma, Mali, Mauritania, Niger, Nigeria, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria	Brooms or other articles made from corn or broomstraw	All countries except Canada
	That held or covered coffee: **If burlap or jute -** Afghanistan, Algeria, Bangladesh, Burkina Faso, Burma, Cyprus, Egypt, India, Iran, Iraq, Israel, Libya, Mali, Mauritania, Morocco, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, Turkey	Burlap or Jute: Used	**When containing articles -** Afghanistan, Algeria, Bangladesh, Burkina Faso, Burma, Cyprus, Egypt, India, Iran, Israel, Libya, Mali, Mauritania, Morocco, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, Turkey
	That held or covered root crops: All countries.		

Table 3 (continued): Nonfood Imports Requiring Methyl Bromide Fumigation or an Alternative Treatment as a Condition of Entry (continued)

Commodity	Description and Country	Commodity	Description and Country
Corn Cobs, Husks, Shanks, or Silks	Canada	Gums	**As bulk cargo or in used burlap or jute bags-** Afghanistan, Algeria, Bangladesh, Burkina Faso, Burma, Cyprus, Egypt, India, Iran, Iraq, Israel, Libya, Mali, Mauritania, Morocco, Niger, Nigeria, Pakistan, Saudi Arabia, Senegal, Sri Lanka, Sudan, Syria, Tunisia, Turkey
Dried Ears of Corn	Canada		
Corn Fodder, Hay Silage, or Stover	All Countries	Hay, Fodder, Silage, Stover, and Straw (not corn, broomcorn, rice, sugarcane, wheat)	All countries except Canada, New Zealand, or Norway
Cottonseed	All countries except Northern European		
Cotton Covers	All Countries Except Northern European	Hibiscus	**Unprocessed seed for analytical, industrial, or other nonfood use** All Countries
Cotton Lint	All Countries except Northern European	Okra	**Unprocessed seed for analytical, industrial, or other nonfood use** All countries
Cotton Linters	All countries except Northern European	Rice Hulls or Rice Straw	All countries
Cotton Waste	All countries except Northern European	Rice Straw -- Baskets	North Korea
Cut Flowers: Includes any flower that's not attached to roots	All countries	Rice Straw -- Hats	All Countries
Goatskins, Lambskins, Sheepskins	Not tanned, blue-chromed, pickled in mineral acid, or salted and moist India, Sudan	Screens, Wooden	India

TABLE 3 (CONTINUED): NONFOOD IMPORTS REQUIRING METHYL BROMIDE FUMIGATION OR AN ALTERNATIVE TREATMENT AS A CONDITION OF ENTRY (continued)

COMMODITY	DESCRIPTION AND COUNTRY	COMMODITY	DESCRIPTION AND COUNTRY
SEEDS FOR PROPAGATION	ABELMOSCHUS SPP. (OKRA, AMBRETTE) ALL COUNTRIES CASTANEA SPP. (CHESTNUT) ALL COUNTRIES GOSSYPIUM SPP. (COTTONS, STURTS'S DESERT-ROSE) ALL COUNTRIES HIBISCUS SPP (MALLOW) ALL COUNTRIES LATHYRUS SPP. (ROUGH PEA) ALL COUNTRIES EXCEPT NORTH OR CENTRAL AMERICA LENS SPP. (LENTIL) ALL COUNTRIES EXCEPT SOUTH, NORTH, OR CENTRAL AMERICA QUERCUS SPP. (ACORN, OAK) ALL COUNTRIES EXCEPT CANADA, MEXICO VICIA SPP. (BROADBEAN, COMMON VETCH, FAVA BEAN, HAIRY OR WINTER VETCH, HAWAIIAN VETCH, WINDSOR BEAN, WOOLY-POD VETCH)	SWEET PEA AND OTHER PEAS (CALEY, CHICKLING, EVERLASTING, FLAT, GRASS, PERENNIAL, ROUGH, SWEET, TANGIER, YELLOW)	UNPROCESSED SEEDS FOR ANALYTICAL, INDUSTRIAL, OR OTHER NONFOOD USE ALL COUNTRIES EXCEPT NORTH AND CENTRAL AMERICA
		VETCH	UNPROCESSED SEEDS ALL COUNTRIES EXCEPT CANADA, MEXICO, OR CENTRAL AMERICA
		WHEAT STRAW	NOT INTENDED FOR DECORATION ALL COUNTRIES EXCEPT: AFGHANISTAN, ALGERIA, AUSTRALIA, BANGLADESH, BULGARIA, CANADA, CHILE, CHINA, CYPRUS, EGYPT, FALKLAND ISLANDS, GREECE, GUATEMALA, HUNGARY, INDIA, IRAN, IRAQ, ISRAEL, ITALY, JAPAN, LIBYA, MEXICO, MOROCCO, NEPAL, NEW ZEALAND, NORTH KOREA, NORWAY, OMAN, PAKISTAN, PORTUGAL, ROMANIA, SOUTH AFRICA, SOUTH KOREA

Sources: USDA, APHIS, PPQ. Plant Import: Nonpropagative.
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Note: Source material for Section I was derived from the NAPIAP survey mentioned at the beginning of this section.

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